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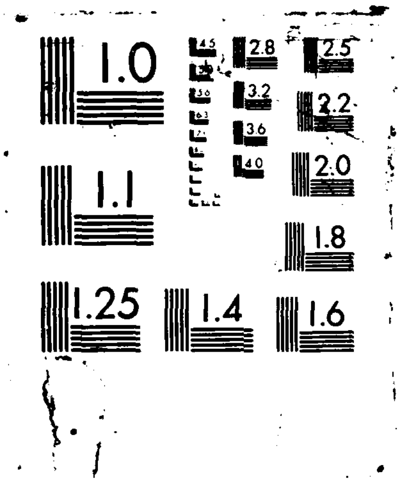
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# NAVAL POSTGRADUATE SCHOOL
## Monterey, California

# THESIS



THE IMPACT OF ONBOARD MAINTENANCE
TRAINING ON SURFACE SHIP READINESS

by

Carl A. Morris

December 1987

Thesis Advisor David R. Whipple

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# The Impact of Onboard Maintenance Training on Surface Ship Readiness

by

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

Analysis of shipboard equipment failure rates generated by merging Navy casuality report and Unified Industries Onboard Maintenance Training (OMT) data bases demonstrate a measurable positive effect on reliability in those ships which participated in the program. When comparing equipment failure rates of these trained ships before and up to three years after the training event, over 70 percent of the time there was definite net positive effect. This positive effect was not found to be statistically significant at normally recognized levels ($\alpha \leq .1$), but the effect is readily apparent. Eleven OMT courses, comprising 1176 shipboard training events over six years were examined. Equipment failure rates for trained units are compared before training with those for the three years following training. While the analytical results of this thesis present quantiative evidence of the positive effect of OMT on equipment readiness, this study also discusses the significant economic efficiency of the program as an alternative to contracted equipment repair.

# THESIS DISCLAIMER

The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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# ACKNOWLEDGEMENTS

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# I. INTRODUCTION

## A. BACKGROUND

The Department of Defense (DOD) is a unique internal labor force primarily because it "trains technicians, it does not hire them" [Ref. 1: p. 142]. Annual Department of Defense (DOD) resources programmed for training approached $20 billion during Fiscal Year (FY) 1986. The Navy alone committed over 17 percent of its available manpower and more than $5 billion to training in some form during FY 1986 [Ref. 2: p. IX-3 & X-4]. As this country's technological advantage over it's principal national security threat narrows and the sheer numerical size disparity continues to widen, the skill of servicemembers effectively employing and maintaining expensive high technology weapons systems will become even more critical. The type and quality of skills provided the military labor force today will have a dramatic impact on force readiness tomorrow and far into the future. Current fiscal realities demand that military managers achieve the largest incremental improvement in national security for each dollar spent. Perceived efficiencies often do not provide sufficient justification to expand or even continue productive programs. DOD and congressional budget decision makers must be given hard facts, sound analysis, and realistic recommendations on which to base calculations needed in arriving at optimal defense program mix.

The ability to relate different training programs to increases in productivity would provide decision makers necessary information on which to base Program, Planning, and Budgeting (PPB) choices. In the training discipline, a majority of the body of knowledge explains the design and execution of programs. Most training research examines individual performance by testing immediately after and at intervals following training. Such research merely measures mental retention of training rather than any incremental change in productivity of the trainee as a member of a labor force or, in the DOD case, a military unit. Tying military training techniques to changes in force readiness is the goal of this thesis.

The Navy's Onboard Maintenance Training (OMT) program is the specific training vehicle through which changes in surface ship material readiness will be studied in this thesis. Ship material readiness will be measured by changes in failure

rates for several classifications of equipment as reported by the Casualty Report (CASREPT) system.

## B. OBJECTIVE

The goal of this thesis is to explore differences in shipboard selected equipment readiness using the criterion of crew participation in the Navy Onboard Maintenance Training (OMT) program. Using Unified Industrie's OMT data base and the Center for Naval Analyses' CASREPT data base, the linkage between specialized crew training and equipment failure rates will be analyzed.

In addition to failure rate analysis, the economic efficiency of OMT as both a pseudo-embedded training program and an equipment repair method will be discussed. This discussion centers on a comparison of training costs for OMT and Navy skill progression, C-school training. An example of repair cost savings will compare successful contract bids for equipment repair found in the Commerce and Business Daily (CBD) with total costs of OMT repairs of identical equipment.

## C. SCOPE AND ASSUMPTIONS

### 1. Scope

The focus of this research is to examine the direct impact Onboard Maintenance Training has had upon fleet equipment readiness as measured by failure rates generated from CASREPT data. This study does not attempt to construct a sophisticated model designed to explain the multitude of inputs and their relative importance in producing ship readiness. Further, this thesis will not conduct an extensive cost benefit analysis of the OMT program. Rather, by applying the concepts of previous training cost studies and discussing an example of the cost of a contracted equipment repair and comparing the cost with that of the OMT alternative, conclusions relative to the budgetary efficiency of the program will be drawn.

### 2. Assumptions

The primary assumption in this research is all other inputs to ship readiness are held constant across class. The study methodology dissects readiness by 11 categories of equipment found on 21 types of surface ships (See Table 1 and 2). Any concerns over this primary assumption are minimized by the large sample size. Almost five years of maintenance data from October 1982 to March 1987 are examined. Classwide statistics are generated from over 90,000 CASREPTs during the study period.

TABLE 1

CATEGORIES OF EQUIPMENT STUDIED

Air Conditioning and Refrigeration
Air Compressor
Centrifugal Pump
Degaussing
Dehydrator
Electric Motor
Firefighting
Mk 19 Gyro Compass
Steam Valve and Regulator
60/400 HZ Converter
60/400 HZ Motor Generator

TABLE 2

TYPES OF SURFACE SHIPS STUDIED

| *SHIP TYPE* | *DESIGNATION* |
|---|---|
| AD | Destroyer Tender |
| AE | Ammunition Supply |
| AO | Oiler |
| AOR | Oiler and Refrigerated Stores |
| AR | Tender |
| CG | Guided Missile Cruiser |
| CGN | Guided Missile Cruiser Nuclear |
| DD | Destroyer |
| DD-963 | Spruance Class Destroyer |
| DDG | Guided Missile Destroyer |
| DDG-993 | Kidd Class Guided Missile Destroyer |
| FF | Frigate |
| FF-1052 | Knox Class Frigate |
| FFG | Guided Missile Frigate |
| FFG-7 | Perry Class Guided Missile Frigate |
| LCC | Amphibious Command |
| LHA | Amphibious Helicopter Carrier |
| LPD | Landing Platform Dock |
| LPH | Landing Platform Helicopter |
| LSD | Landing Ship Dock |
| LST | Landing Ship Tank |

Another major assumption is that CASREPT data accurately and objectivly reflect ship maintenance performance. Opinions have been voiced [Ref. 3: p.16] that CASREPT data are not an entirely appropriate performance measure. The most serious shortcoming of this reporting system is that, while the criteria for filing CASREPTs is well documented (an equipment failure affecting a ship's primary

mission area not correctable within 48 hours), many commands practice "gamesmanship" in adhering to these guidelines. This individual command effect is minimized by the fact that classwide statistics are generated over a long time period. Other assumptions includes that:

- The results of other studies used are reliable.
- The data provided by Unified Industries C.N.A. and other Navy sources are reliable.

## D. SUMMARY OF FINDINGS

Analysis of failure rates generated by merging the CASREPT and Unified Industries OMT training data bases found a measurable positive effect on equipment reliability in those ships which participated in the program. When comparing equipment failure rates of these trained ships before and up to three years after the training event, over 70 percent of the time there was a definite net positive effect. This positive effect was not found to be statistically significant at normally recognized levels ($\alpha \leq .1$), but the effect is readily apparent.

Table 3 presents results of this study for the eleven OMT courses examined. Equipment failure rates for trained units are compared before training ($\lambda_1$) with those for the three years following training ($\lambda_2$). Those courses displaying positive effects ($\lambda_1 - \lambda_2 > 0$) comprise 70 percent of the OMT training events studied.

While the analytical results of this thesis present quantitative evidence of the positive effect of OMT on equipment readiness, there is also a significant economic efficiency of the program as an alternative to contracted equipment repair. One cost comparison provided by Unified Industries presented the cost of a class C overhaul on an Ingersoll Rand low pressure air compressor. The contracted price for this repair advertised in the C.B.D (Commerce Business Daily) fluctuated between $85,000 and $115,000. The OMT repair expenses included the manufacturer's overhaul kit $29,000, the cost of the instructor for three weeks $3,000, and a portion of the military pay and benefits for the five sailors involved during the training period. Allowing this opportunity cost of the crewmembers to vary considerably the identical OMT repair is easily half the cost of the contracted work. The economic efficiencies of shipboard training are addressed later in this study.

TABLE 3

FAILURE RATES BY COURSE (TRAINED UNITS, 3 YEAR TIME HORIZON)

| *COURSE* | $\lambda_1 - \lambda_2$ | *PVALUE* |
|---|---|---|
| AC&R | .000084 | .99 |
| AIR COMP | .000519 | .99 |
| CENTPUMP | .000034 | .94 |
| DE | -.000081 | .34 |
| DRY AIR | -.000155 | .40 |
| ELEC MOT | .000018 | .70 |
| FIRE | .000379 | .99 |
| MK 19 | .000207 | .83 |
| STEAMVAL | -.000101 | .12 |
| 60/400HZ | .000971 | .97 |
| 60/400MG | -.000278 | .48 |

$\lambda_1$ - Failure Rate w/o OMT

$\lambda_2$ - Failure Rate /w OMT

## E. ORGANIZATION OF STUDY

Chapter II provides background for this study by explaining the general structure of Navy training. A brief history of the Onboard Maintenance Training Program and it's contribution to fleet self-sufficiency is also presented.

Previous research which applies to this thesis is discussed in the Chapter III literature review. Studies in training, and military readiness, concentrating on productivity, efficiency, and budget cost comprise the bulk of this chapter.

In Chapter IV, the methodology used in creating the data bases and the alternative experimental designs are discussed. An explanation of the appendices dealing with FORTRAN programs is also provided. Remarks on the statistical analysis of the data, results of the study, and the SPSSX and SAS programs used is dealt with in Chapter V.

Concluding remarks and policy recommendations are made inlight of the results in the final chapter. Chapter VI also provides ideas for further studies using the Unified Industries and CASREPT data bases.

## II. BACKGROUND

### A. NAVY TRAINING OVERVIEW

To understand how Onboard Maintenance Training affects shipboard material readiness, an explanation of the general structure of Navy training is needed. Specifically, since it is the enlisted ratings which conduct equipment maintenance aboard ship, it is their training that will be the primary focus.

Navy enlisted occupational standards identify the tasks of each Navy rating by paygrade within each rating. Tasks within the occupational standards fall generally into categories of operation, maintenance, or management. These standards are intended to form the basis upon which enlisted personnel are trained, assigned to duty, and demonstrate qualifications for advancement in rate. Specialized tasks requiring training, but not included in the occupational standards because only a small percentage of the rate need carry them out, are grouped into Navy Enlisted Classification (NEC) codes. Enlisted billets in each command are identified in the Ship Manning Document (SMD) by rating, rate, and, if applicable, one or more NEC codes.

#### 1. Shore Based Training

The Navy Enlisted Personnel Distribution System, in conjunction with the Navy Training System, seeks to match skills required by "spaces" with the skills of "faces" available for assignment. Enroute training provides the opportunity to correct skill deficiencies which may exist between the billet requirement and the personnel assigned. The training system available for this purpose is comprised primarily of shore-based resident military schools, to which individuals are assigned as a duty station, to develop the skills required of their next assignment.

Another portion of the shore-based school system is the installation support school, usually located in areas of fleet concentration at Fleet Training Centers (FTC). Installation support schools are organized to meet local training needs, although they conduct a large number of courses which are duplicated at other schools. Students are normally sent from their commands on a temporary duty under instruction basis, for return to the parent command after training.

Remaining training that is conducted is accomplished within each command and is referred to as onboard training. When the command is a ship, this training is

called shipboard training. The conduct of shipboard training is the responsibility of the ship's Commanding Officer, with oversight responsibility flowing up through the Fleet chain of command.

### 2. Shipboard Training

The principal objective of shipboard training is to prepare a crew to perform effectively as members of the many teams needed to operate and fight a ship. The development of individual skills to support performance as a team member is dependent upon the rating involved. The amount of rate training provided in shore schools prior to reporting aboard ship varies significantly across ratings. Initial specialized training for some ratings emphasizes operational training, to facilitate qualification as an underway watchstander as soon after reporting aboard as possible. For a number of ratings, there is practically no formal training provided prior to the member's reporting aboard. Thus the shipboard skill environment requires a training program tailored to meet specific needs of each group of ratings.

Operator watchstanding training normally receives the majority of formal shipboard training time and resources. Watchstander training is managed through the theory, systems, and watch sections of the Personnel Qualification Standards (PQS) program. Except in commands with self-designed formal maintenance training, there is generally no such program available.

There is a general understanding within the Fleet that maintenance training is important, but the limited resources of time and skills, and the priority placed on operator training has resulted in maintenance training being diminished. Thus, the lack of a fleetwide formal maintenance training program aboard ship is due more to the lack of any effective delivery system and training resource material than it is to a perception of lessor need.

It was in this almost nonexistent maintenance training environment that the Navy of the late 1970s found itself. To compound this situation, 1976 through 1980 was one of the bleakest periods of careerist retention for the Navy in recent history. With experienced and skilled senior enlisted manpower at an ebb, Fleet commanders began observing a degradation in ship material readiness [Ref. 4]. With no near- term prospects of improvement, emergency intensive care was needed to restore shipboard maintenance to self-sufficiency.

## B. CONTRACTED MAINTENANCE TRAINING

### 1. Shop Qualification Improvement Program (SQIP)

Commander Naval Sea Systems Command (NAVSEA) as the technical hardfare manager for the Navy, in 1976, recognized the existence of a shortage in skilled personnel at fleet Intermediate Maintenance Activities (IMA). Productivity of these important sailor-manned repair organizations, both tenders and ashore, was declining. In 1977 NAVSEA code 041 initialized the Shop Qualification Improvement Program (SQIP). Through this program, contracted civilian[1] instructors provided industrial repair skill and management training to all surface and submarine IMAs including industrial level shops on aircraft carriers (CVs). NAVSEA envisioned this program as a fix in three important areas. First, repair skill training would improve the capabilities of IMAs and facilitate their execution of NAVSEAs equipment and ship class maintenance strategies. Second, by requiring highly qualified, experienced instructors, the Systems Command now had the ability to provide technical improvements and guidance face to face in addition to routine documentation. Third, and perhaps most unexpected, instructor post training reports enabled NAVSEA to receive personal feedback from the fleet on which the technical community could react.

In 1977 NAVSEA contracted courses in 17 IMA industrial repair skill areas. Planning Research Company (PRC) conducted courses in 12 of the skill areas and Unified Industries Incorporated (UII) provided the remaining 5. The SQIP program today conducts 23 skill area courses as well as the management, documentation, and advanced technical support delineated in the program's 1977 charter.[2] Fiscal Year 1986 funding for SQIP was $4.32 million. [Ref. 5]

### 2. Onboard Maintenance Training (OMT)

Both surface type commanders recognized the inherent rationale of "hands on" maintenance training and saw the positive effect the infant SQIP was having on IMA productivity. Late in 1977, Commander Surface Force Atlantic Fleet petitioned the chain of command to provide onboard SQIP type training as a pilot program on 600 and 1200 psi propulsion ships. The Chief of Naval Operations approved a pilot program in June 1978 with the objective of evaluating the concept for possible

[1]Civilian is not an accurate description for these instructors. All were retired Navy Chief Petty Officers in repair ratings with at least six years of IMA experience, and Navy instructor training.

[2]This information was provided via phone conversations with Mr. Bob D'orsy Unified Industries, San Diego, California.

expansion and inclusion in the 1981 POM (Program Operation Memorandum).

A pilot centrifugal pump repair course was conducted in 1979 on both coasts by PRC. The results of the pilot program were predictable. Shipboard pump maintenance teams trained during the program immediately started to work overhauling other pumps and training fellow crew members in repairs which would have been otherwise deferred for off ship accomplishment.

The unqualified success of the pilot program in the fleet resulted in its expansion to 23 equipment courses. Funding for OMT in fiscal year 1986 was only $850,000. To understand why SQIP blossomed while OMT, with perhaps an even greater potential, did not, one must delve into Navy politics.

Almost from the inception of the two training programs, their sponsor, NAVSEA, sought to transfer their cognizance from the material command to the training command. NAVSEA's position was articulated as follows in a 1981 point paper:

> In accordance with NAVMATINST 5460.2A, the personnel and training support functions of the Naval Sea Systems Command are limited to advising officials of the Department of the Navy, as appropriate, on training and technical requirements for the operation and maintenance, by Naval personnel, of equipment under development, and for providing equipment, technical data, support, and documentation for the operation and maintenance of material for which NAVSEA has support responsibilities. The OMT program has evolved to include administration of major field training operations.
>
> With OMT now well established, it should be organizationally realigned to become part of the Navy Training System with respect to program policy, objectives, funding, and management control. Such placement will permit its operation and growth to be coordinated with existing and other new initiatives in onboard training assistance being developed, such as the Shipboard Propulsion Plant Operator Training (SPPOT) project. However, it is acknowledged that there is not currently a centralized organizational structure in the Navy to manage onboard training assistance projects. Using the OMT program as a catalyst and pilot program, the development of such a capability within the Navy could proceed expeditiously.[3]

Chief of Naval Education and Training (CNET) did not wish to further broaden his area of responsibility by assuming control of the OMT program. CNET position was presented as follows:

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[3]This material is from an organizational plan outline to shift management responsibility for Onboard Maintenance Training (OMT) from NAVSEA to OPNAV, dated 22 October 1981.

Formal training cannot continue to be increased indefinitely to meet intensifying demands for additional training, because of time, funding, and instructor personnel constraints. The difference in training requirements and formal training available will be filled by onboard training (OBT). The OBT available is currently at a multitude of levels from shipboard generated, to Systems Commands and OPNAV sponsored, and contractor prepared. Frequently OBT is not coordinated between the many sponsoring activities resulting in duplication of effort, extensive resource requirements, and confusions in the fleet and shore stations as to OBT program procurement and implementation. Central to this theme is the requirement for the designation of an organization to centrally manage the OBT program within the Navy.[4]

CNET recommended that a branch within OPNAV be created to manage onboard training. This debate concerning onboard training continues to this day. Under the sponsorship of OPNAV (OP-43), NAVSEA's contracting support and technical oversight, and Type Commander (TYCOM) day-to-day direction and scheduling, OMT as continued at relativly low funding levels. Funding levels were so low that support of courses in two homeports were cancelled in 1985.

## C. FUTURE OF HIGH-TECH SKILLS

With the advent of ever more complex propulsion, weapons, and support systems on fleet units, both new construction and backfitted, the modern Navy is demanding a greater number of specialized skills in shipboard crews. Training pipelines can stretch several months between duty stations attempting to match billet needs with personnel skills. The further expansion of shore-based training with its inherent loss of service member productivity is not an appropriate answer to the problem.

The current solution, reliance on civilian technical representatives (TECHREP) to repair shipboard systems procured from their corporations, is also not appropriate. In 1985 the Chief of Naval Operations (CNO) directed[5] the reduction of Navy dependence on afloat civilian TECHREPs [Ref. 6: p. 126]. His July 1987 TECHREP elimination date has passed uneventfully and afloat civilian skilled workers remain a reality for the Navy. The Navy appears to accept this overall civilianization trend when it announced in 1986:

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[4]This material is quoted from a Chief of Naval Education and Training letter to OPNAV dated 1 April 1981, signed by his deputy at the time, J.M. Poindexter.

[5]Memorandum, Adm. James D. Watkins to the deputy chiefs of naval operations for submarine warfare, surface warfare, and air warfare. "Civilian Engineering Technical Service (CETS) Personnel," 5 April 1985.

. Continuing efforts are underway within Navy to reduce the overall level of military manpower requirements through civilianization.[6]

The Navy goes on to rationalize this labor substitution trend by noting the significant savings of trained military manpower this program has allowed.

The efficiency in civilian labor over military, in some missions, should not be lost on manpower planners. Civil service assumption of military billets or TECHREP repair of complex shipboard equipment, including aircraft, is not the best form of civilianization, although they have become quite popular. Rather, private contracting of support and training manpower appears to present concrete avenues for savings. The skilled military trained technicians that left the service causing experience shortfalls can now be contracted to provide the very same services, but as civilians. Lower overhead and a willingness to work in the familiar military environment at possibly below market wage (excluding the sunk cost of retirement pay) would enable the Navy to capture a cost savings. The economic efficiency of competitive contracting is in the early stages throughout DOD. Using low-cost labor to liberate military manpower for more critical purposes can lower the price and improve program efficiency, particularly in manpower-intensive missions such as training.

Shipboard maintenance managers are finding an ever increasing gap between equipment installed and personnel with necessary skills to effect onboard repair to that equipment. A case in point is the auxiliary propulsion equipment on Spruance class destroyers (DD-963). The rating assigned repair responsibility over firepumps, air compressors, and the LM2500 gas turbine engine is the same, Gas Turbine Mechanic (GSM). While GSM A and C school training[7] prepares these students for many turbine-related malfunctions, personnel in this rating receive almost no background in basic repair of the peripheral propulsion equipment. Designed redundancy in auxiliaries has attempted to replace the need for self-sustainability in these vessels.

This trend toward reliance on outside maintenance of shipboard equipment manifests itself in the minimally-manned Oliver Hazard Perry Class (FFG-7). Designed equipment failure rates, requisite equipment duplication, and regularly scheduled

[6]Office of the Assistant Secretary of Defense (Manpower, Installation and Logistics). *Military Manpower Training Report for FY 1986 Vol III and IV*. Washington, D.C.: Department of Defense, 1985. pp.IV-38.

[7]Class A school training is basic skill instruction normally provided following recruit training. C school training is designed as a first term reenlistment incentive for sailors with fleet experience.

Industrial Maintenance Availabilities (IMAV), which conduct class maintenance plan replacement of installed auxiliaries, is a way of life on these ships. Variances in equipment failure rates, supply availability of reworked carcasses, and ship employment detract from the success of this repair philosophy. Fleet Engineering Officers on these classes of ships have found OMT to have great impact on their self-sufficiency.

Senior Navy officials, both NAVSEA and Fleet Commanders, recognized the need for a program to improve shipboard equipment maintenance self-sufficiency in 1978. The SQIP and OMT programs were developed and evaluated as successfully meeting these hands-on maintenance training goals. Unfortunately, while the NAVSEA-tasked IMA-centered SQIP has flourished, the equally effective shipboard program has been stagnated by unclear sponsorship and training area responsibility. The crucial question is, had the OMT program received full support and appropriate funding over the past seven years what would the Navy's mission readiness be? To more fully comprehend the possible impact OMT could have on the fleet, an understanding of productivity and training and military readiness is required. The next chapter will review literature associated with these areas.

# III. LITERATURE REVIEW

The body of knowledge as it applies to this thesis exists in three general disciplines: productivity, training, and military readiness. The interaction of researchers in these areas has produced several works on both training efficiency and military readiness productivity. The assimilation of this literature as well as graduate studies provided a sound theoretical foundation on which to frame this study.

## A. MILITARY READINESS PRODUCTIVITY

An excellent summary of literature concerning military productivity research is provided by Horowitz [Ref. 3: p. 13-28]. In this paper, he also develops a causal chain that links Manpower, Personnel, and Training (MPT) policy decisions to increased readiness. He explains the feasibility of transforming this chain into a set of quantitative planning instruments. One of the most important discussions in Horowitz's evaluation concerns directing MPT analysts toward the use of available quantifiable data rather than the use of subjective survey data. The merging of these already available partial indicators of performance into a substantially improved indication of military output will provide a measure upon which MPT policies can be formed and expenditures justified. The use of CASREPT data in this thesis is one of the quantifiable data types mentioned by Horowitz. The OMT data base is again an example of the untapped data MPT researchers could use to study training programs. The combination of these data bases in the two forms provided in this thesis can be used in tangent studies of training methods and equipment reliability.

Warner [Ref. 7], in an earlier paper with much the same theme, summarizes the then current knowledge of Navy manpower problems and focuses on possible directions for future studies. Warner develops a theoretical framework for evaluating manpower issues in terms of supply and demand. He stresses the issue of quantifying military demand with efficient measurements. Readiness, the output of military labor, is examined in this thesis. If training programs such as OMT can improve the productivity of military labor it follows that demand can be reduced. This thesis proceeds from Warner's recommendation for research in both readiness and training disciplines.

Hogan [Ref. 8] discusses a broad range of efficiency and productivity topics, as they apply to Defense manpower issues. He examines and critiques DOD techniques designed to promote efficiency in manpower determination, hardware experience mix tradeoffs, and the efficiency impact on the All-Volunteer-Force. This article provided a general knowledge of the budgetary decision process within DOD. Programs such as OMT which contribute to efficiency in two areas, maintenance and training, should receive high budgeting priority.

An early study which used CASREPT data as a criterion measure of surface ship productivity was conducted by Horowitz and Sherman in 1977 [Ref. 9]. They examined the performance of maintenance ratings on surface ships. Aggregate ship statistics were developed from the enlisted master file of every crewmember on 91 ships studied. These data were then weighted by the individual's length of duty on the ship during the study period. The enlisted characteristics, examined by occupation include crew size, Armed Forces Qualification Test (AFQT) scores, education, past sea experience, rank, length of service, marital status, race, and training courses attended. One of the effects they observed was that variations in productivity reflected variations in training in all ratings except Firecontrol Technicians (FT). These findings predict an observable effect on ship readiness caused by a maintenance training program such as OMT. Including other than formal training as a variable captured in the data bases produced in this thesis, may explain even more fully variances in ship readiness.

Horowitz [Ref. 10] condensed several previous studies concerning Navy enlisted productivity conducted while he was at the Center for Naval Analyses. In this monograph, Horowitz suggests how these studies might apply to Army manpower issues. Knowledge of previous studies and research methods prevents analysts continually reinventing the wheel. This review serves this important purpose, as well as demonstrating the similarity of manpower issues among military services.

A 1984 study conducted at the U.S. Military Academy [Ref. 11] examined the impact of mental groups and high technology on tank crew performance. This research suggested that advanced technology weapons systems need not require the high quality operators the Services claim. The theme of this study is that technology may make systems increasingly easier to operate, but the same is not necessarily true for maintenance tasks on these more complex systems. The impact of advancing technology on the Navy has not gone unnoticed. The requirement to compete in the electronic environments above, below, and on the high seas has created a reliance on

high-tech weapons, communication, and propulsion systems. These systems maybe user friendly, but tend to require ever increasing experience levels in maintenance personnel.

Howell [Ref. 12] models the effect the experience levels of maintenance crews have on the Air Force F-4E sortie generation. His research concluded that more experienced, skill-level 5 maintenancemen were over 25 percent more productive than the lower experienced skill-level 3 personnel. This contention that productivity is a function of time-on-the-job opens the prospect for improvement in the skill-generating activities of on-the-job training. Programs such as OMT may, in fact, shorten the time required to transition to a more productive skill level.

The damaging effects increased personnel turbulence has on civilian productivity have been well documented. The effect of turbulence on military units has more recently been studied by Tragemann [Ref. 13]. He discovered significant improvements in unit readiness by stabilizing individuals within deploying units using the Army Cohesion Operational Readiness and Training System (COHORT). Entire unit reassignment is not new to the Services. The Navy Fleet Ballistic Missile Force established blue and gold crew rotation from its inception. This personnel policy sought to increase production of strategic deterrence by more efficient use of existing capital investments, SSBNs. This turbulence effect is not lost on the the surface Navy. The gapping of critically skilled billets while awaiting in-route shore training of reliefs can adversly affect unit readiness. If a policy of reducing shore school duration by transferring a portion of the training to more productive on-the-job training were in place, personnel would spend greater amounts of time actually onboard each ultimate duty station.[8] OMT provides an efficient program to expand crew experience levels in specilized maintenance skills without prolonging existing off-ship training pipelines.

## B. TRAINING EFFECTIVENESS

As the Navy seeks to improve force productivity, research into more efficient training methods may produce as large a gain as advancing technology. To be fair, high technology applications in the training field are themselves opening new vistas requiring cost-benefit analyses. Research by Balis [Ref. 14] was mainly concerned with estimating skill and experience mix and the level of reenlistment bonus necessary to maintain an efficient force structure. Of interest to this study is his mechanism for

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[8] An ultimate duty station is the final reporting activity on an individual's transfer orders. In the case of a servicemember being transferred to a ship via shore schools, this process may span more than a year.

estimating initial training costs of recruits. If programs can be developed which provide the necessary skills to these new sailors more economically than the existing shore-based training system, skill thresholds or the number of students trained could be increased.

Marcus and Questor [Ref. 15] investigate occupation-specific learning curves of first-term Navy enlisted personnel, using the Rand Corporation's Enlisted Utilization Survey (EUS). The purpose is to estimate the Navy's sunk-cost payback horizon for varied length service schools. The study estimates the minimum length of obligated service required for the Navy to recoup this investment in human capital. These training cost estimates for specialized training are of interest to this thesis.

Two related studies by Questor [Ref. 16] and Downey [Ref. 17] seek to explain to the Chief of Naval Operations (CNO) why quality of life improvements of the early 1980s improved retention but did not realize the anticipated savings in reduced training costs. These studies reveal that Navy enlisted endstrength proportions have moved toward more careerists, and these career designated sailors, by definition, require higher levels of specialized skill training. Additionally, specialized skill training at the C-school level has expanded significantly.

These two studies document the fact that C schools are the most manpower-intensive Navy skill training. While the Training command has embarked on an expansion in these military labor intensive schools, the cost of that labor has risen dramatically. One conclusion that can be drawn from these studies is that continued reliance upon shore-based, military manpower-intensive skill training is not the most efficient use of scarce training dollars or military manning. The OMT program is a direct competitor for the specialized skill training dollars spent to support some maintenance related C schools. It is crucial that the military sharpen it's ability to recognize and implement training programs which are more effective or economic than those currently in place.

Malehorn [Ref. 18] provides an excellent theoretical framework to explore the cost-benefit relationship of embedded training.[9] He develops a series of Strawman statements which represent possible effeciencies of the embedded training method.

[9] Embedded training is training that is provided by capabilities built into or added onto operational systems, subsystems, or equipment to maintain and or enhance the skill proficiency of fleet personnel. Further, an embedded training device is designed and manufactured as an integral part of an operational system's hardware software or consists of separately developed external hardware software which interfaces with an operational system.

Programs such as OMT, which use existing equipment to conduct skill training, in the broad sense, qualify as embedded training. This Strawman technique of exploring the cost-benefit relationship of OMT contrasted to the more traditional methods of imparting specilized skills is one way of conducting a cost evaluation of different training programs. Many of Malehorn's possible embedded training payoffs are realized by OMT. These applicable payoffs include:

- All travel, billeting, subsistance, and administrative costs associated with moving students to the instruction site are avoided.
- Costs associated with maintaining formal schools i.e., capital investments, personnel costs of instructors and staff, and base support expenses are foregone.
- Students opportunity costs are lower than in formal schools as they remain available for partial shipboard military duty.
- Training is conducted on specific shipboard equipment with immediate student applicability. Learning is quickly reenforced with greater mental retention.
- OMT training overhauls shipboard equipment which would otherwise require off ship repair facilities to conduct the repair.

This literature review would be incomplete without mention of work conducted by Reslock and Gregory [Ref. 19] in preparing the Center for Naval Analyses CASREPT data base. This explanation of the CASREPT data base was clear, concise, and error-free. Ms. Reslock was the point of contact at the Center for Naval Analyses for the CASREPT data base used in this thesis. Her rapid response to requests for data and sound explanations were instrumental to this work.

The literature reviewed for this thesis has charted the course for the use of quantitative measures of military productivity, the CASREPT data base, to study a specialized maintenance skill training program, which utilizes the economic efficiency of a shipboard embedded training environment.

# IV. METHODOLOGY

## A. DATA MANIPULATION

The two files used to conduct this investigation are the Center for Naval Analyses CASREPT data base from October 1982 to March 1987, and the Unified Industries Training Data base from January 1981 to July 1987. The CASREPT file consists of over 149,000 data points and the Unified file of over 26,000 data points. Record layout for the CASREPT data base is provided in CNA report 86-28 [Ref. 19: Appendix B]. Layout for the entire Unified Industries data base is provided in Appendix A of this thesis.

Before any data manipulation could take place the data bases contained on magnetic tape were loaded on to the Naval Postgraduate School computer center mass storage system. Programs 1 and 2 in Appendix B upload the UNIFIED Industries and CASREPT data respectivly.

### 1. Uploading Tapes and Data Reduction

The first step in using these two files was to conduct descriptive statistics on the variables contained within them. Of particular interest were the two OMT sections of the Unified data set. This data set contained individual crewmember training data and ship data as separate subfiles. As this study explores the total effect of OMT on ship readiness, only the ship files were considered. There are over 1,300 training events during the period studied in this subfile.

Ship class selections were made to reduce the total number of calculations while maintaining adequate sample size. The ship class selections shown in Table 2 represent 94.4 percent of the OMT ship training file. Identical rationale was relied upon in making equipment course selections from the OMT file. Those skill areas shown in Table 1 comprise 93.1 percent of the total training file. These selections allowed 87.1 percent or 1,176 OMT training events to be analyzed during this study. These frequencies can be found in Appendix B section 3.

The next step was to match the OMT training courses with equipment identification codes (EIC).[10] EIC's are one of the data fields provided in each

[10] An equipment identification code is a four character code used to exactly identify specific Navy equipments. These codes are contained in the Navy's *Equipment Identification Code Manual* [Ref. 20].

CASREPT record. The eleven OMT courses correspond to 110 EICs. The relationship between courses and EICs is contained in the FORTRAN program found in Appendix E. By relating each OMT equipment course to the corresponding EIC's on which the training is applicable, the CASREPT records for those EICs are examined. Program 3 Appendix B creates the subset of the OMT file for Table 2 ships training records. Program 4 Appendix B separates only those CASREPTs from ships in Table 2 and EICs corresponding to training courses in Table 1.

### 2. Creating a Dummy OMT Training Variable

Before both the OMT and CASREPT files can be operated on together, data fields containing ship hull number and all dates must be in identical formats. Ship hull numbers in the Unified files were changed to match the CASREPT form. Thus, AOR-5 becomes AOR 0005. Training dates on the OMT data base were in a six-digit year, month, day form. Because failure rates were to be computed in failures per equipment days these training dates were converted to the pseudo-Julian date configuration found in the CASREPT file. This sequential date counter begins with day 00001 on 1 January 1974. These operations are accomplished on the subset.Unified file by program 5 found in Appendix C. Program 6 in the same Appendix is an SPSSX procedure used to sort this file (subset.Unified1) by ship hull number, course title, and training date creating subset.Unified2 on the mass storage system. This second sorted subset of the OMT data base was used as input to the failure rate calculation program in Appendix E.

Now the CASREPT and associated ship OMT files can be read and related to each other in a single program. The FORTRAN program in Appendix D reads each ship's training data, hull number, course name, and course date, contained in the subset.Unified1 file and then searches the CASREPT file for reported failures in each EIC covered by that particular course. The mass storage file created by this program contains ship identification data, total down time for the CASREPT, the breakdown of down time by supply and maintenance, the EIC involved, and a field relating to OMT in the form of a 0,1 entry. The dummy OMT variable will be 0 if OMT had not been conducted on the CASREPT EIC within three years.[11] A 1 is found in this field if training had been provided by OMT within the three year time frame.

[11] A three year training effect period was chosen in light of current expected sea tour lengths of the maintenance ratings targeted by the OMT program. One and two year training effect horizons were also examined and will be discussed in Chapter V.

This CASREPT OMT data base allows investigation of differences in the variables contained in the CASREPT file. Variations in the amount of equipment down time and the portion of the down time that is supply or maintenance related could be examined. This study was centered on the comparison of equipment failure rates and this combined CASREPT OMT dummy file measured only equipment down time. A file which captured failures and equipment life was needed.

### 3. Generating Failure Rates

Because the OMT dummy file depended upon the report of casualties to equipment to derive an indication of changing reliability, the generation of a more appropriate failure rate file was required. The Appendix E FORTRAN program creates this file. The failure rate procedure divides the CASREPT file into control and treatment groups with OMT training conducted within three years of the CASREPT being the treatment. To calculate failure rates, casualties must be counted and then divided by a total time variable.

Equipment time is computed from each ship's initial begining CASREPT date to the end of the CASREPT file (31 March 1987) for each of the 110 EICs. All ships begin in the control group and some migrate into the treatment group when onboard training occurs. Ships may also move back into the control group when the 1095 day (three year) training effect clock runs out. Failures are counted by ship and EIC depending on whether the CASREPT happened during a training or non-training period.

Now that time in equipment days and failures have been found the program sums each ship's EIC control and treatment data by class of ship. The resulting file contains ship class, failures and time during non-trained periods, non-trained failure rate, failures and time during trained periods, trained failure rate, EIC, and the associated OMT course title.

The file described above was then filtered by removing all EICs for which there were no failures in the control and treatment groups. This reflected the fact that some classes of ships do not have all 110 equipments installed or that the equipment simply did not fail as reported by the CASREPT system. In either case this data was of no use to the study.

Identical summed failure rate data bases were created using one and two year training effect time values. A FORTRAN program creating an alternate experimental design is also included in Appendix E. This methodology examines only ships which

participated in OMT.[12] These ships equipment failure rates prior to the training event comprise the control group, failure rates following specific courses produce the treatment rates. Again, three data bases were created using the three, two, and one year training effect horizon. The summed failure rate data bases were small enough to reside on the authors A disk allowing easy access for statistical analysis. These six failure rate files were compared statistically during the analysis phase of this study.

This analysis will be presented in the following chapter.

## B. OVERVIEW

This chapter has explained the raw data used, the transformation of that raw data into a usable form and the creation of four new data sets on which statistical analysis can be conducted. In the next chapter the statistical procedures applied to the three summed failure rate files, and results are discussed.

[12] This methodology was recommended by Dr. Loren M. Solnick, Department of Administrative Sciences, Naval Postgraduate School.

# V. DATA ANALYSIS AND RESULTS

## A. DATA ANALYSIS

### 1. Computing Aggregated Failure Rates and F-Statistic

The data bases produced by the two Appendix E FORTRAN programs and the one and two year training experience horizon variants of them, provide failure data by class of ship, EIC, and OMT course title. These data are already the aggregation of data from ships within the class. An SPSSx program was used to further aggregate failure and equipment time data. Summed failures and equipment time were used to compute trained and non-trained failure rates which were in turn compared by computing F-statistics and degrees of freedom. By altering the BREAK line of the Appendix F section A program using class, EIC, or course this analysis is conducted on all combinations required.

### 2. Test for Statistical Significance

Failure rates follow the exponential distribution and as such the generalized likelihood ratio test is from the F-distribution. When the failure rate of equipment with no OMT (control) is $\lambda_1$, and failure rates of equipment having OMT (treatment) is $\lambda_2$, the test the hypothesis $H_0 : \lambda_1 = \lambda_2$ is provided by Equation 5.1.

$$F_{\alpha/2, n_1, n_2} \leq \frac{2(\sum T_1)2(1+g_2)}{2(\sum T_2)2(1+g_1)} \qquad \text{(eqn 5.1)}$$

Where $T_1$ and $T_2$ represent equipment time and $g_1$ and $g_2$ are the number of observations, in this case the number of casualties in each sub group (control or treatment) [Ref. 21: p 456]. These values F, $n_1$, and $n_2$ are computed by the SPSSx program mentioned above from $T_1$, $T_2$, $g_1$, and $g_2$.

It was necessary to use SAS to calculate observed level of significance or p values, as SPSSx has no direct method to accomplish this procedure. An example of the SAS program using the SPSSx output is presented in section B of Appendix F. The p values produced by SAS are combined with the associated failure rate difference, $\lambda_1$-$\lambda_2$ in the tables presented in the next chapter. Together the differences and p values depict the change in equipment failure rates between the control and treatment groups

and the statistical significance of the change. Negative values for this difference reflect lower equipment failure rates in the control group than in the treatment group.

## B. RESULTS

Logic and previous research suggests that OMT should reduce equipment failure rates on participant units. Those ships having crewmembers with the ability to correctly operate, diagnose and repair equipments onboard should realize increased equipment reliability. This study found that there was in fact a net positive effect associated with ships that had received OMT training. While this positive effect was not statistically significant at normally accepted levels, the data demonstrate improved equipment failure rates in a clear majority of ships (70 percent) on which training had taken place. Oddly enough, the positive effect of maintenance training on failure rates was found to intensify with time. This time horizon effect holds true for both experimental designs, all units in the control group and trained units only in control groups.

TABLE 3
FAILURE RATES BY COURSE (TRAINED UNITS, 3 YEAR TIME HORIZON)

| *COURSE* | $\lambda_1-\lambda_2$ | *PVALUE* |
|---|---|---|
| AC&R | .000084 | .99 |
| AIR COMP | .000519 | .99 |
| CENTPUMP | .000034 | .94 |
| DE | -.000081 | .34 |
| DRY AIR | -.000155 | .40 |
| ELEC MOT | .000018 | .70 |
| FIRE | .000379 | .99 |
| MK 19 | .000207 | .83 |
| STEAMVAL | -.000101 | .12 |
| 60/400HZ | .000971 | .97 |
| 60/400MG | -.000278 | .48 |

$\lambda_1$ - Failure Rate w/o OMT
$\lambda_2$ - Failure Rate /w OMT

This study's results are presented in Table 3 through Table 6 in this chapter and in Table 7 through Table 12 in Appendix G. The results are arranged by first examining OMT's effect with only trained ships in the control group, then with all ships in the control group.

TABLE 4

FAILURE RATES BY CLASS (TRAINED UNITS, 3 YEAR TIME HORIZON)

| *CLASS* | | $\lambda_1 - \lambda_2$ | *PVALUE* |
|---|---|---|---|
| AD | | .000462 | .86 |
| AE | | .000484 | .99 |
| AO | | .000564 | .92 |
| AOR | | .000006 | .54 |
| AR | | -.000520 | .08 |
| CG | | .000196 | .97 |
| CGN | | .000843 | .98 |
| DD | | .000795 | .97 |
| DD | 0963 | .000043 | .74 |
| DDG | | .000083 | .87 |
| DDG | 0993 | .000996 | .84 |
| FF | | -.000241 | .09 |
| FF | 1052 | -.000085 | .09 |
| FFG | | -.000590 | .04* |
| FFG | 0007 | -.000570 | .24 |
| LCC | | -.000181 | .47 |
| LHA | | -.001012 | .07 |
| LPD | | -.000118 | .18 |
| LPH | | .000488 | .99 |
| LSD | | .000026 | .56 |
| LST | | .000177 | .92 |

$\lambda_1$ - Failure Rate w/o OMT

$\lambda_2$ - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

1. **Trained Units in Control Group**

The results in Table 3 reproduced here from Chapter I, Table 4, and Table 7 through 9 represent analysis of the three data bases produced considering only units on which OMT was conducted. These results demonstrate the net positive effect of OMT on improving equipment reliability. This positive effect is not found to be statistically significant at accepted levels of significance ($\alpha \leq .1$), however the overall effect is none-the-less very positive.

With this experimental design 61 percent of ship classes, 65 percent of EICs, and in fully 70 percent of OMT training events studied exhibit an improvement in equipment reliability for up to three years after participating in this training program. Again, this more positive effect intensifies as time from the training date increases.

The concentration of OMT training events in a few classes of ships biases class-wide results. The more important observation is what effect does OMT have on reliability of types of equipments regardless of the platform on which it is installed. Of

equal importance is the question of what areas and courses, produce the greatest impact on equipment reliability. For these two topics a more realistic analysis of training events by course is provided. Results in this section will be presented with the more meaningful course statistics preceding the unevenly weighted class tables.

**2. All Units in Control Group**

Table 5, Table 6, and Table 10 through Table 12 are the analysis of the three summed failure rate data bases produced incorporating all ships, trained and non-trained, into the control group. As previously mentioned the numbers of classes displaying positive effects increases with longer time horizons. Actual failure rates in failures per equipment day are provided in Table 6 with rate differences. The extremely small size of the fractions involved in some cases create havoc with tests for significance. For example in Table 5 only five of the eleven courses studied show a positive effect and none are significant at $\alpha \leq .1$, these five include 53.4 percent of the training conducted. The electric motor course comprises another 17 percent of the training events and a negligible difference of .000004 or 1 failure in 250,000 equipment days moves this course into the negative effect category.

TABLE 5

FAILURE RATES BY COURSE (ALL UNITS, 3 YEAR TIME HORIZON)

| *COURSE* | *PVALUE* | $\lambda_1$ | $\lambda_2$ | $\lambda_1 - \lambda_2$ |
|---|---|---|---|---|
| AC&R | .97 | .000425 | .000375 | .000050 |
| AIR COMP | 1.00 | .002923 | .002297 | .000626 |
| CENTPUMP | .58 | .000625 | .000618 | .000007 |
| DE | .19 | .000225 | .000257 | -.000031 |
| DRY AIR | .46 | .000595 | .000574 | .000022 |
| ELEC MOT | .37 | .000033 | .000036 | -.000004 |
| FIRE | .99 | .000128 | .000054 | .000074 |
| MK 19 | .02* | .000428 | .000575 | -.000147 |
| STEAMVAL | .03* | .000432 | .000529 | -.000097 |
| 60/400HZ | .09 | .001499 | .001852 | -.000353 |
| 60/400MG | .00* | .001128 | .001673 | -.000545 |

$\lambda_1$ - Failure Rate w/o OMT

$\lambda_2$ - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

By further dividing OMT courses into specific EICs, fully 60 percent of equipments enjoy improved reliability as a result the training. Only six EICs display significant negative effects of the 65 found to exist on classes of ships studied.

TABLE 6

FAILURE RATES BY CLASS (ALL UNITS, 3 YEAR TIME HORIZON)

| CLASS | | PVALUE | $\lambda_1$ | $\lambda_2$ | $\lambda_1 - \lambda_2$ |
|---|---|---|---|---|---|
| AD | | .01* | .000483 | .000735 | -.000252 |
| AE | | .88 | .000395 | .000324 | .000071 |
| AO | | .10 | .000620 | .000792 | -.000172 |
| AOR | | .57 | .000478 | .000454 | .000024 |
| AR | | .15 | .000572 | .000751 | -.000179 |
| CG | | .96 | .000735 | .000633 | .000102 |
| CGN | | .99 | .000812 | .000337 | .000475 |
| DD | | .29 | .000420 | .000477 | -.000057 |
| DD | 0963 | .78 | .000376 | .000343 | .000032 |
| DDG | | .97 | .000640 | .000568 | .000072 |
| DDG | 0993 | .00* | .000785 | .002059 | -.001274 |
| FF | | .01* | .000724 | .000910 | -.000185 |
| FF | 1052 | .45 | .000435 | .000438 | -.000003 |
| FFG | | .73 | .000929 | .000801 | .000129 |
| FFG | 0007 | .00* | .002552 | .004351 | -.001799 |
| LCC | | .04* | .000782 | .001337 | -.000555 |
| LHA | | .00* | .000796 | .002708 | -.001912 |
| LPD | | .34 | .000754 | .000780 | -.000026 |
| LPH | | .86 | .000852 | .000739 | .000113 |
| LSD | | .00* | .000419 | .000683 | -.000264 |
| LST | | .40 | .000423 | .000436 | -.000013 |

$\lambda_1$ - Failure Rate w/o OMT

$\lambda_2$ - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

In the final chapter conclusions and recommendations based on these results be presented and discussed.

# VI. CONCLUSIONS AND RECOMMENDATIONS

## A. CONCLUSIONS

This study has attempted to be an unbiased evaluation of the impact onboard maintenance training has on equipment reliability on several classes of U.S. Navy surface ships. The results presented in this thesis demonstrate that specific OMT courses produce improved reliability on certain equipment. While this effect is not statistically significant at normally recognized levels, the positive effect is measurable.

It appears that this positive effect manifests itself in two interesting ways. First, it is observed when failure rates are compared before and after training (trained units only in control group) rather than comparing trained ship failure rates with those of non-trained ships. One rationale for this result is that ships participating in OMT have a real need for the training. It is reasonable to assume that a unit experiencing problems with certain types of equipment, without sufficiently trained maintenance personnel to elevate the situation, i.e. higher failure rates, would benefit the most from training such as that provided by OMT.

The second phenomenon observed is most probably caused by an aberration in the CASREPT data used for this study. The observation that trained units failure rates improve as the duration of time from the training date was initially counter-intuitive. An understanding of the CASREPT file produces the most likely answer. There is more than one piece of equipment of a particular EIC on each ship. However these equipments are not differentiated in the CASREPT data studied. In reality failure rates were computed in failures per ship EIC days rather than equipment days. As all ships and EICs were treated uniformally the comparisons of these values remain insightful, but not perfect. This improvement with time effect could result from OMT ships exercising new found talents of repair on identical types and identification coded equipments shortly following completion of the training course. The fact that these repairs often require more than 48 hour duration, results in a CASREPT being filed and this studies trained failure rate rising during the first year. Including a specific equipment identifier in the CASREPT data which is included as part of the required message format would correct this problem.

Onboard Maintenance Training makes good sense from both an economic and personnel productivity view point. Equipment is repaired to class C overhaul standards at a fraction of the expense of having it done off the ship, and very expensive specialized skill training is conducted again at a fraction of the off ship cost. While it was beyond the scope of this thesis to produce a cost benefit analysis of the training costs involved, the economics of embedded training over off ship training appear significant.

Based on this evaluation of the quantifyable variables and an application of principles discussed in Chapter III this author concludes that OMT has a definite net positive effect on both Navy readiness and budget efficiency.

## B. RECOMMENDATIONS

### 1. For Further Studies

The uses of the data bases created in this thesis abound. Possible uses include:

- Inclusion of an OMT training variable in a multivariate analysis of ship readiness.
- Conduct an extensive cost study of Navy specialized training and OMT.
- Analysis of the pre-test post-test data contained in the OMT Student Detail section of the Unified data.
- Analysis of the parts, tools, and technical documentation onboard sections of the OMT Ship Detail file.
- Use of the SQIP training records and IMA production records to evaluate training efficiency.
- SQIP Student Detail pre-test and post-test as for OMT.
- Correct the equipment identification problem in the CASREPT data encountered during this thesis and rerun this study.
- Use the CASREPT file as a dependent variable in other studies.

### 2. For Onboard Maintenance Training

It is the strong recommendation of this author that Onboard Maintenance Training be expanded to include not only engineering skill areas but also weapons, communications, and electronic repair. Increased funding for this expansion of OMT could be provided by transfer of a portion of existing Type Commander maintenance funds. With rising shipyard manhour costs and existing civilian contracted repair costs, OMT is a more productive use of each Type Commander repair dollar than any other alternative.

# APPENDIX A
# RECORD LAYOUT FOR UNIFIED INDUSTRIES DATA

This is the layout for the Unified Industries data base. There are six sub files contained within this data base. Particular data sets are differentiated by the contents of positions one and two.

## 1. SHIP MASTER

```
DATA SET NUMBER        PIC X(02) VALUE '01'
HULL/TYPE              PIC X(9)
FILLER                 PIC X
SHIP NAME              PIC X(20)
FLEET                  PIC X(8)
```

## 2. SQIP MASTER

```
DATA SET NUMBER        PIC X (02) VALUE '02'
SQIP COURSE CODE       PIC X (8)
SQIP COURSE NAME       PIC X (29)
FILLER                 PIC X
```

## 3. OMT MASTER

```
DATA SET NUBMER        PIC X (02) VALUE '03'
OMT COURSE CODE        PIC X (8)
OMT COURSE NAME        PIC X (25)
FILLER                 PIC X
```

## 4. SQIP STUDENT DETAIL

```
DATA SET NUMBER        PIC X (02) VALUE '04'
STUDENT NAME           PIC X (14)
NAVY RATE              PIC X (4)
E RATE                 PIC XX
HULL TYPE              PIC X (9)
FILLER                 PIC X
SQIP COURSE CODE       PIC X (8)
SQIP COURSE TYPE       PIC X (4)
SQIP COURSE TYPE-G     REDEFINES
FILLER                 PIC XX
    INITIAL VISIT      VALUE "IV"
    REVISIT            VALUE "RV"
    FOLLOW ON VISIT    VALUE "FO"
FILLER                 PIC XX
BEGINNING DATE         PIC 9 (6)
ENDING DATE            PIC 9 (6)
LOCATION               PIC X (12)
INSTRUCTOR             PIC X (14)
COMPLETION CODE        PIC X
FILLER                 PIC X
WRITTEN PRE TEST       PIC 999  COMP
WRITTEN POST TEST      PIC 999  COMP
HANDS-ON PRE TEST      PIC 999  COMP
HANDS-ON POST TEST     PIC 999  COMP
HOURS LECTURE          PIC 99   COMP 8 TIMES
HOURS OJT              PIC 99   COMP 8 TIMES
```

## 5. OMT STUDENT DETAIL

| | |
|---|---|
| DATA SET NUMBER | PIC X (02) VALUE '05' |
| STUDENT NAME | PIC X (14) |
| NAVY RATE | PIC X (4) |
| E RATE | PIC XX |
| PRD | PIC 9 (4) COMP |
| HULL TYPE | PIC X (9) |
| FILLER | PIC X |
| OMT COURSE CODE | PIC X (8) |
| FILLER | PIC XX |
| BEGINNING DATE | PIC 9 (6) |
| ENDING DATE | PIC 9 (6) |
| LOCATION | PIC X (12) |
| INSTRUCTOR | PIC X (14) |
| COMPLETION CODE | PIC X |
| FILLER | PIC X |
| WRITTEN PRE TEST | PIC 999 COMP |
| WRITTEN POST TEST | PIC 999 COMP |
| HANDS-ON PRE TEST | PIC 999 COMP |
| HANDS-ON POST TEST | PIC 999 COMP |
| HOURS LECTURE | PIC 99 COMP 8 TIMES |
| HOURS OJT | PIC 99 COMP 8 TIMES |

## 6. OMT SHIP DETAIL

```
DATA SET NUBMER        PIC X (02) VALUE '06'
HULL TYPE              PIC X (9)
FILLER                 PIC X
OMT COURSE CODE        PIC X (8)
OMT COURSE TYPE        PIC XX
   INITIAL VISIT       VALUE "IV"
   FOLLOW-ON VISIT     VALUE "FO"
BEGINNING DATE         PIC 9 (6)
ENDING DATE            PIC 9 (6)
FOLLOW-ON DATE         PIC 9 (6)
LOCATION               PIC X (12)
INSTRUCTOR             PIC X (14)
REMAINING ONBOARD      PIC 999    COMP
ONGOING TRAINING       PIC X
FILLER                 PIC X
INSTRUCTORS GUIDE      PIC X
FILLER                 PIC X
SIMILAR REPAIRED       PIC 999    COMP
NO MORE REPAIR         PIC 999    COMP
DEF DATA
   TOOLS PRE           PIC 9 (4)
   TOOLS POST          PIC 9 (4)
   TECH DOC PRE        PIC 9 (4)
   TECH DOC POST       PIC 9 (4)
   REPAIR PARTS PRE    PIC 9 (4)
   REPAIR PARTS POST   PIC 9 (4)
REPAIR DATA
COMPLETE REPAIRS       PIC 99
AWAITING PARTS         PIC 99
REQUIRE IMA            PIC 99
```

```
REQUIRE DEPOT        PIC 99
NOT ENOUGH TIME      PIC 99
```

## 7. SAMPLE OF UNIFIED SHIP DETAIL FILE

```
06DD-963    60/400HZIV821122821203000000ATLANTIC     CEWARD
06DD-963    ELEC MOTIV821220821230000000ATLANTIC     CEWARD
06DD-963    ELEC MOTIV831107831118000000ATLANTIC     J PINKER
06DD-963    STEAMVALIV831031831118000000ATLANTIC     JEHUDSON
06DD-963    AC&R     IV831107831125000000ATLANTIC     C CONLEY
06DD-964    CENTPUMPIV850624850628000000PACIFIC      M LINCOL
```

## 8. SAMPLE OF CASREPT FILE

```
20574DD  096382100601500320128211020322800280026000210624 1S5HEG
20574DD  096382100720200320228210210321600150000001510000 0R3550
20574DD  096382101321160320828301220330901020000010210000 1SQM59
20574DD  096382101502160321028301250331201030018008510432 2RGWFC
20574DD  096382101811500321328211100323600240019000510456 1RG321
```

# APPENDIX B
# TAPE READING TO MASS STORAGE SYSTEM

## 1. UNIFIED DATA TO MASS STORAGE

```
//NPS528    JOB (2908,9999),'X0002 TAPE1',CLASS=E
//*MAIN  RINGCHK=NO
//  EXEC PGM=IEBGENER
//SYSPRINT DD SYSOUT=A
//SYSIN  DD DUMMY
//SYSUT1 DD DISP=SHR,DSNAME=MSS.S2908.UNIFIED
//SYSUT2 DD UNIT=3400-6,VOL=SER=NPS528,DISP=(NEW,PASS),
//            LABEL=(1,NL,,OUT),
//            DCB=(RECFM=FB,LRECL=200,BLKSIZE=19000,DEN=3)
```

## 2. CASREPT TAPE TO MASS STORAGE

```
//X0003     JOB (2908,9999),'X0003 FORTRAN',CLASS=F
//  EXEC FORTVCG
//FORT.SYSIN DD *
      CHARACTER*57 A
      CHARACTER*20 B
      CHARACTER*1  BLK
      DATA BLK/' '/
      INDEX = 0
   10 CONTINUE
      READ(1,20,END=100) A,B
   20 FORMAT(A57,1X,A20)
      INDEX = INDEX + 1
      WRITE(2,30) A,BLK,B
   30 FORMAT(A57,A1,A20)
      GO TO 10
  100 CONTINUE
      WRITE(6,110) INDEX
  110 FORMAT(1X,'RECORDS TRANSFERRED:',I8)
      STOP
      END
/*
//GO.FT01F001 DD UNIT=3400-6,VOL=SER=X0003,DISP=(OLD,PASS),
//    LABEL=(1,NL,,IN),
//    DCB=(RECFM=FB,LRECL=78,BLKSIZE=780,DEN=3,OPTCD=Q)
//GO.FT02F001 DD DISP=(OLD,KEEP),
//    DCB=(RECFM=FB,LRECL=78,BLKSIZE=19032),
//    DSN=MSS.S2908.CASREP
```

## 3. SELECT OMT SHIP MASTER AND SHIPS STUDIED FROM UNIFIED FILE

```
//UNIFIED  JOB (2908,9999),'UNIFIED SPSSX',CLASS=A
//    EXEC SPSSX
//DD1 DD DISP=SHR,DSN=MSS.S2908.UNIFIED
//DD2 DD UNIT=SYSDA,DISP=(OLD,KEEP),
// DCB=(RECFM=FB,LRECL=60,BLKSIZE=19020),
// SPACE=(19020,(4,1)),DSN=MSS.S2908.SUBSET.UNIFIED
//SYSIN DD *
DATA LIST  FILE=DD1 / TYPE 1-2 CLASS 3-5(A) COURSE 13-20(A)
 BEGDATE 23-28(A)  ENDDATE 29-34(A) LOCAL 41-48(A) INSTRUCT 53-60(A)
 XXX 1-60(A)
SELECT IF (TYPE EQ 06)
IF  (CLASS EQ 'AD-') FLAG = 1
IF  (CLASS EQ 'AE-') FLAG = 1
IF  (CLASS EQ 'AO-') FLAG = 1
IF  (CLASS EQ 'AOR') FLAG = 1
IF  (CLASS EQ 'AR-') FLAG = 1
IF  (CLASS EQ 'CGN') FLAG = 1
IF  (CLASS EQ 'DDG') FLAG = 1
IF  (CLASS EQ 'FFG') FLAG = 1
IF  (CLASS EQ 'FF-') FLAG = 1
IF  (CLASS EQ 'DD-') FLAG = 1
IF  (CLASS EQ 'CG-') FLAG = 1
IF  (CLASS EQ 'LCC') FLAG = 1
IF  (CLASS EQ 'LKA') FLAG = 1
IF  (CLASS EQ 'LPD') FLAG = 1
IF  (CLASS EQ 'LPH') FLAG = 1
IF  (CLASS EQ 'LSD') FLAG = 1
IF  (CLASS EQ 'LST') FLAG = 1
SELECT IF (FLAG = 1)
WRITE   OUTFILE=DD2 /   XXX 1-60 (A)
EXECUTE
/*
```

## 4. UNIFIED DATA FREQUENCIES

0CLASS

0

| VALUE LABEL | VALUE | FREQUENCY | PERCENT | VALID PERCENT | CUM PERCENT |
|---|---|---|---|---|---|
| | AD | 16 | 1.4 | 1.4 | 1.4 |
| | AE | 56 | 4.8 | 4.8 | 6.1 |
| | AO | 16 | 1.4 | 1.4 | 7.5 |
| | AOR | 34 | 2.9 | 2.9 | 10.4 |
| | AR | 20 | 1.7 | 1.7 | 12.1 |
| | CG | 111 | 9.4 | 9.4 | 21.5 |
| | CGN | 24 | 2.0 | 2.0 | 23.6 |
| | DD | 185 | 15.7 | 15.7 | 39.3 |
| | DDG | 175 | 14.9 | 14.9 | 54.2 |
| | FF | 214 | 18.2 | 18.2 | 72.4 |
| | FFG | 54 | 4.6 | 4.6 | 77.0 |
| | LCC | 14 | 1.2 | 1.2 | 78.1 |
| | LKA | 7 | .6 | .6 | 78.7 |
| | LPD | 71 | 6.0 | 6.0 | 84.8 |
| | LPH | 54 | 4.6 | 4.6 | 89.4 |
| | LSD | 55 | 4.7 | 4.7 | 94.0 |
| | LST | 70 | 6.0 | 6.0 | 100.0 |
| | | ------- | ------- | ------- | |
| | TOTAL | 1176 | 100.0 | 100.0 | |

0VALID CASES    1176      MISSING CASES    0

OCOURSE

0

| VALUE LABEL | VALUE | FREQUENCY | PERCENT | VALID PERCENT | CUM PERCENT |
|---|---|---|---|---|---|
| | AC&R | 196 | 16.7 | 16.7 | 16.7 |
| | AIR COMP | 165 | 14.0 | 14.0 | 30.7 |
| | CENTPUMP | 181 | 15.4 | 15.4 | 46.1 |
| | DE | 46 | 3.9 | 3.9 | 50.0 |
| | DRY AIR | 22 | 1.9 | 1.9 | 51.9 |
| | ELEC MOT | 204 | 17.3 | 17.3 | 69.2 |
| | FIRE | 64 | 5.4 | 5.4 | 74.7 |
| | MK 19 | 30 | 2.6 | 2.6 | 77.2 |
| | STEAMVAL | 218 | 18.5 | 18.5 | 95.7 |
| | 60/400HZ | 35 | 3.0 | 3.0 | 98.7 |
| | 60/400MG | 15 | 1.3 | 1.3 | 100.0 |
| | TOTAL | 1176 | 100.0 | 100.0 | |

OVALID CASES 1176 MISSING CASES 0

## 5. SELECT SHIPS AND EICS STUDIED FROM CASREPT FILE

```
//CASREPT  JOB (2908,9999),'CASREP SPSSX',CLASS=G
//    EXEC SPSSX
//DD1 DD DISP=SHR,DSN=MSS.S2908.CASREP
//DD2 DD UNIT=SYSDA,DISP=(NEW,CATLG),
//     DCB=(RECFM=FB,LRECL=64,BLKSIZE=19008),
//     SPACE=(19008,(400,40)),
//     DSN=MSS.S2908.SUBSET.CASREP
//SYSIN DD *
DATA LIST FILE=DD1 /UIC 1-5  CLASS 6-9(A) HULL 10-13  BEGDATE 14-19
  MAINDOWN 49-52 OPEN 53 CAUSE 59(A) REPLVL 60(A) EIC 61-64(A)
  TOTDOWN 41-44 SUPDOWN 45-48 SHIP 6-13(A)
  XXX 1-64(A)
IF  (CLASS EQ 'AD' ) FLAG = 1
IF  (CLASS EQ 'AE' ) FLAG = 1
IF  (CLASS EQ 'AO' ) FLAG = 1
IF  (CLASS EQ 'AOR') FLAG = 1
IF  (CLASS EQ 'AR' ) FLAG = 1
IF  (CLASS EQ 'CGN') FLAG = 1
IF  (CLASS EQ 'DDG') FLAG = 1
IF  (CLASS EQ 'FFG') FLAG = 1
IF  (CLASS EQ 'FF' ) FLAG = 1
IF  (CLASS EQ 'DD' ) FLAG = 1
IF  (CLASS EQ 'CG' ) FLAG = 1
IF  (CLASS EQ 'LCC') FLAG = 1
IF  (CLASS EQ 'LKA') FLAG = 1
IF  (CLASS EQ 'LPD') FLAG = 1
IF  (CLASS EQ 'LPH') FLAG = 1
IF  (CLASS EQ 'LSD') FLAG = 1
IF  (CLASS EQ 'LST') FLAG = 1
SELECT IF (FLAG = 1)
SELECT IF ANY (EIC,'TF01','TF03','TF04','CC01','CC03','EB03','KF01',
     'KF03','TLOF','TLOG','TLOH','TLOJ','LBOM','LBON','LBOP','LBOQ',
     'K703','K705','F703','F705','4708','4704','4703','F301','F303',
     'F308','F309','F30A','F30C','F30D','F30E','F30G','F30H','FB01',
     'FB05','FB06','FB07','E901','E905','E907','E909','K301','K303',
     'K308','K309','K30A','K30C','K30D','K30E','K30G','K30H','KA01',
     'KA05','KA06','KA07','T707','T708','T401','T403','T404','T405',
     'T406','T407','T408','T409','T40S','T40T','T501','T504','N401',
     'N403','N404','N405','N406','N407','N408','N409','N40A','N40B',
     'N40C','N40D','N40E','N40F','N40G','N40H','N40J','N40K','N40L',
     'N40M','N40N','N40P','N40Q','N40R','N40S','N40T','N40U','N40V',
     'N40W','N40X','T901','T903','T904','T405','T906','T907','T908',
     'T909','T911','T90A','T90C')
WRITE   OUTFILE=DD2 /   XXX 1-64 (A)
EXECUTE
/*
```

# APPENDIX C
## UNIFIED DATA TRANSFORMATION

```
//RDDATA   JOB (2908,9999),'RDDATA FORTRAN',CLASS=A
//  EXEC FORTVCG
//FORT.SYSIN DD *
      CHARACTER*1  BLK,DASH,B2
      CHARACTER*2 B1
      CHARACTER*4 UTYP(1351),UNUM(1351)
      CHARACTER*8 UCNAME(1351),C2
      CHARACTER*9 CC
      INTEGER UYR(1351),UMON(1351),UDAY(1351),UDATE(1351)
      INTEGER NDAYS(12)
      DATA NDAYS/0,31,59,90,120,151,181,212,243,273,304,334/
      DATA BLK/' '/,DASH/'-'/
      DATA UTYP/1351*'    '/
      DATA UNUM/1351*'0000'/
      I=1
    1 CONTINUE
    2 FORMAT(A2,A4,A4,A1,A8,A8,I5)
      READ(1,5,END=9) B1,CC,B2,UCNAME(I),C2,UYR(I),UMON(I),UDAY(I)
    5 FORMAT(A2,A9,A1,A8,A8,I2,I2,I2)
      IF(UYR(I).EQ.0) GO TO 1
      JJ=0
      J2=0
      DO 7 J=1,9
      J2=J2+1
      IF (JJ.GT.0) GO TO 6
      ID=J
      IF (CC(J:J).EQ.DASH) GO TO 6
      UTYP(I)(1:J)=CC(1:J)
      GO TO 7
    6 CONTINUE
      JJ=JJ+1
      IF(CC(J:J).EQ.BLK) GO TO 8
    7 CONTINUE
    8 CONTINUE
      UNUM(I)(7-JJ:4)=CC(ID+1:J2-1)
      UDATE(I)=(UYR(I)-74)*365+NDAYS(UMON(I))+UDAY(I)
      WRITE(2,2)B1,UTYP(I),UNUM(I),B2,UCNAME(I),C2,UDATE(I)
      I=I+1

      GO TO 1
    9 CONTINUE
      WRITE(6,110) I-1
  110 FORMAT(1X,'RECORDS TRANSFERRED:',I8)
      STOP
      END
/*
//GO.FT01F001 DD DISP=(OLD,KEEP),
//    DCB=(RECFM=FB,LRECL=60,BLKSIZE=19020),
//    DSN=MSS.S2908.SUBSET.UNIFIED
//GO.FT02F001 DD DISP=(NEW,CATLG,DELETE),SPACE=(19020,(40,10)),
//    DCB=(RECFM=FB,LRECL=60,BLKSIZE=19020
//    DSN=MSS.S2908.SUBSET.UNIFIED1,UNIT=SYSDA
***** SORT SUBSET.UNIFIED ONE BY SHIP, COURSE, AND DATE

//UNIFIED  JOB (2908,9999),'UNIFIED SPSSX',CLASS=B
//    EXEC SPSSX
//DD1 DD DISP=SHR,DSN=MSS.S2908.SUBSET.UNIFIED1
//DD2 DD UNIT=SYSDA,DISP=(OLD,KEEP),
// DCB=(RECFM=FB,LRECL=60,BLKSIZE=19020),
// SPACE=(19020,(4,1)),DSN=MSS.S2908.SUBSET.UNIFIED2
//SYSIN DD *
```

```
DATA LIST  FILE=DD1 / TYPE 1-2 SHIP 3-10(A) COURSE 12-19(A)
 UDATE 29-32 XXX 1-60(A)
SORT CASES BY SHIP(A) COURSE(A) UDATE(A)
WRITE   OUTFILE=DD2 /   XXX 1-60 (A)
EXECUTE
/*
//
```

## APPENDIX D
## COMBINED CASREPT AND OMT FILE

```
//DATA    JOB (2908,9999),'EIC FORTRAN',CLASS=J
//   EXEC FORTVCLG,REGION.GO=1500K
//FORT.SYSIN DD *
      PARAMETER (NEIC=110,NSHIP=700)
      CHARACTER*1  B2,REP(500)
      CHARACTER*2 B1
      CHARACTER*4 UTYP(1351),UNUM(1351),EICTBL(NEIC),CEIC(500)
      CHARACTER*5 A1
      CHARACTER*6 D1,E1
      CHARACTER*8 UCNAME(1351),C2,CRSTBL(NEIC),SHIP(NSHIP),USHIP(1351),
     .CSHIP(500)
      CHARACTER*9 CC
      CHARACTER*10 C1
      INTEGER UYR(1351),UMON(1351),UDAY(1351),UDATE(1351),CBDATE(500),
     .FLT(500),CEDATE(500),TDOWN(500),SDOWN(500),MDOWN(500),CENSOR(500)
      INTEGER ITABLE(NSHIP,NEIC)
      DATA EICTBL/'TF01','TF03','TF04','CC01','CC03','EB03','KF01',
     .'KF03','TL0F','TL0G','TL0H','TL0J','LB0M','LB0N','LB0P','LB0Q',
     .'K703','K705','F703','F705','4708','4704','4703','F301','F303',
     .'F308','F309','F30A','F30C','F30D','F30E','F30G','F30H','FB01',
     .'FB05','FB06','FB07','E901','E905','E907','E909','K301','K303',
     .'K308','K309','K30A','K30C','K30D','K30E','K30G','K30H','KA01',
     .'KA05','KA06','KA07','T707','T708','T401','T403','T404','T405',
     .'T406','T407','T408','T409','T40S','T40T','T501','T504','N401',
     .'N403','N404','N405','N406','N407','N408','N409','N40A','N40B',
     .'N40C','N40D','N40E','N40F','N40G','N40H','N40J','N40K','N40L',
     .'N40M','N40N','N40P','N40Q','N40R','N40S','N40T','N40U','N40V',
     .'N40W','N40X','T901','T903','T904','T405','T906','T907','T908',
     .'T909','T911','T90A','T90C'/
      DATA CRSTBL/ 2*'AIR COMP',1*'DRY AIR',9*'ELEC MOT',4*'MK 19   ',    X0000070
     . 4*'STEAMVAL',1*'60/400HZ',2*'60/400MG',34*'CENTPUMP',
     .12*'AC&R    ',30*'DE      ',11*'FIRE    '/
      JSHIP=0
      LSHIP=0
      DO 100 I=1,1351
      READ(1,2,END=110)B1,USHIP(I),B2,UCNAME(I),C2,UDATE(I)
    2 FORMAT(A2,A8,A1,A8,A8,I5)
    3 FORMAT(1X,'JSHIP = ',I4)
    4 FORMAT(A5,A8,A10,I5,I1,A6,I5,I4,I4,I4,I1,A6,A1,A4)
    5 FORMAT(A8,1X,I5,1X,I1,1X,I5,1X,3(I4,1X),I1,1X,A1,1X,A4,1X,I1)
    6 FORMAT(1X,'JSHIP',1X,'  SHIP   ','NCASRP')
    7 FORMAT(1X,I4,2X,A8,2X,I4)
C     TEST FOR NEW SHIP
      DO 10 J=1,NSHIP
      IF(SHIP(J).EQ.USHIP(I))THEN
         JJ=J
         GO TO 20
      ENDIF
   10 CONTINUE
C     NEW SHIP
      JSHIP=JSHIP+1
      IF (JSHIP.GT.NSHIP)STOP 'JSHIP.GT.NSHIP'
      JJ=JSHIP
      SHIP(JSHIP)=USHIP(I)
   20 CONTINUE
C     MAKE SHIP/EIC TABLE
      DO 30 J=1,NEIC
      IF (UCNAME(I).EQ.CRSTBL(I)) THEN
         ITABLE(JJ,J)=1
      END IF
   30 CONTINUE
```

```
      WRITE(6,3)JSHIP
  100 CONTINUE
  110 CONTINUE
C     READ CASREP FILE AND PROCESS DATA FOR ONE SHIP AT A TIME
      I=0
      DO 1000 K=1,150000
  200 CONTINUE
      I=I+1
      READ(2,4,END=280)A1,CSHIP(I),C1,CBDATE(I),FLT(I),D1,CEDATE(I)
     .,TDOWN(I),SDOWN(I),MDOWN(I),CENSOR(I),E1,REP(I),CEIC(I)
  250 CONTINUE
      IF(I.EQ.1) THEN
         C2=CSHIP(I)
      ELSE
         IF(CSHIP(I).NE.C2) GO TO 300
      ENDIF
      GO TO 200
  280 CONTINUE
      LSHIP=1
  300 CONTINUE
      NCASRP=I-1
      DO 500 J=1,NSHIP
      IF(C2.EQ.SHIP(J)) THEN
         JSHIP=J
         GO TO 510
      ENDIF
  500 CONTINUE
  510 CONTINUE
      DO 700 N=1,NCASRP
      DO 600 J=1,NEIC
      IF(CEIC(N).EQ.EICTBL(I)) THEN
         JEIC=J
         GO TO 610
      ENDIF
  600 CONTINUE
  610 CONTINUE
      JDUM=ITABLE(JSHIP,JEIC)
      WRITE(3,5)CSHIP(N),CBDATE(N),FLT(N),CEDATE(N),TDOWN(N),SDOWN(I),
     .MDOWN(N),CENSOR(N),REP(N),CEIC(N),JDUM
  700 CONTINUE
      WRITE(6,6)
      WRITE(6,7) JSHIP,C2,NCASRP
C     START NEW SHIP
      I=1
      CSHIP(I)=CSHIP(NCASRP+1)
      CBDATE(I)=CBDATE(NCASRP+1)
      FLT(I)=FLT(NCASRP+1)
      CEDATE(I)=CEDATE(NCASRP+1)
      TDOWN(I)=TDOWN(NCASRP+1)
      SDOWN(I)=SDOWN(NCASRP+1)
      MDOWN(I)=MDOWN(NCASRP+1)
      CENSOR(I)=CENSOR(NCASRP+1)
      REP(I)=REP(NCASRP+1)
      CEIC(I)=CEIC(NCASRP+1)
      IF(LSHIP.EQ.1)GO TO 1100
      GO TO 250
 1000 CONTINUE
 1100 CONTINUE
      STOP                                                              X0000190
      END                                                               X0000200
/*
//GO.FT01F001 DD DISP=SHR,
//   DSN=MSS.S2908.SUBSET.UNIFIED1
//GO.FT02F001 DD DISP=(OLD,KEEP),
//   DSN=MSS.S2908.SUBSET.CASREP
//GO.FT03F001 DD DISP=(NEW,CATLG),SPACE=(19032,(304,10)),
//   DCB=(RECFM=FB,LRECL=78,BLKSIZE=19032),
//   UNIT=SYSDA,
//   DSN=MSS.S2908.OMT
```

## 1. EXAMPLE OF COMBINED CASREPT AND OMT FILE

The following is an example of the output of the combined CASREPT and OMT program. Note this output is for only two ships in the DD 0963 class.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DD | 0963 | 3529 | 2 | 3536 | 8 | 0 | 8 | 1 | T | LBOM | 0 | 0 | 0 |
| DD | 0963 | 3250 | 2 | 3323 | 74 | 72 | 2 | 1 | S | N40S | 0 | 0 | 0 |
| DD | 0963 | 3213 | 2 | 3276 | 64 | 59 | 5 | 1 | S | TF01 | 0 | 0 | 0 |
| DD | 0963 | 3370 | 6 | 3381 | 12 | 10 | 2 | 1 | S | TF01 | 0 | 18 | 0 |
| DD | 0963 | 3445 | 6 | 3466 | 22 | 19 | 3 | 1 | S | TF01 | 0 | 64 | 0 |
| DD | 0963 | 3592 | 2 | 3643 | 52 | 0 | 52 | 1 | R | TF01 | 0 | 126 | 0 |
| DD | 0963 | 3806 | 2 | 3808 | 3 | 0 | 3 | 1 | S | TF01 | 0 | 163 | 0 |
| DD | 0963 | 3813 | 2 | 3821 | 9 | 0 | 9 | 1 | T | TF01 | 0 | 5 | 0 |
| DD | 0963 | 3898 | 2 | 3920 | 23 | 0 | 23 | 1 | T | TF01 | 0 | 48 | 0 |
| DD | 0963 | 3922 | 2 | 3927 | 6 | 3 | 3 | 1 | R | TF01 | 0 | 2 | 0 |
| DD | 0963 | 4232 | 2 | 4253 | 22 | 0 | 22 | 1 | S | TF01 | 0 | 305 | 3614 |
| DD | 0963 | 4328 | 2 | 4354 | 27 | 24 | 3 | 1 | S | TF01 | 0 | 44 | 3614 |
| DD | 0963 | 4360 | 2 | 4372 | 13 | 5 | 8 | 1 | T | TF01 | 0 | 6 | 3614 |
| DD | 0963 | 3323 | 6 | 3364 | 42 | 18 | 24 | 1 | S | TF03 | 0 | 0 | 0 |
| DD | 0963 | 3385 | 6 | 3403 | 19 | 0 | 19 | 1 | S | TF03 | 0 | 21 | 0 |
| DD | 0963 | 3754 | 2 | 3771 | 18 | 0 | 18 | 1 | S | TF03 | 0 | 351 | 0 |
| DD | 0963 | 3807 | 2 | 3833 | 77 | 0 | 77 | 1 | T | TF03 | 0 | 36 | 0 |
| DD | 0963 | 3916 | 2 | 3922 | 7 | 0 | 7 | 1 | S | TF03 | 0 | 102 | 0 |
| DD | 0963 | 3922 | 2 | 3927 | 6 | 2 | 4 | 1 | R | TF03 | 0 | 0 | 0 |
| DD | 0963 | 4179 | 2 | 4265 | 87 | 0 | 87 | 1 | S | TF03 | 0 | 252 | 3614 |
| DD | 0963 | 4265 | 2 | 4324 | 60 | 0 | 60 | 1 | S | TF03 | 0 | 8 | 3614 |
| DD | 0963 | 4320 | 2 | 4354 | 35 | 29 | 6 | 1 | S | TF03 | 0 | 47 | 3614 |
| DD | 0963 | 3626 | 2 | 3662 | 37 | 23 | 14 | 1 | T | TF04 | 0 | 0 | 0 |
| DD | 0963 | 4265 | 2 | 4313 | 49 | 0 | 49 | 1 | R | T40S | 1 | 0 | 3614 |
| DD | 0963 | 4367 | 2 | 4536 | 170 | 0 | 170 | 1 | S | T40S | 1 | 54 | 3614 |
| DD | 0963 | 4126 | 6 | 4159 | 34 | 0 | 34 | 1 | S | T405 | 1 | 0 | 3614 |
| DD | 0964 | 3235 | 3 | 3264 | 30 | 28 | 2 | 1 | S | TF01 | 0 | 0 | 0 |
| DD | 0964 | 3677 | 3 | 3684 | 8 | 1 | 7 | 1 | T | TF01 | 0 | 413 | 0 |
| DD | 0964 | 3711 | 3 | 3747 | 37 | 34 | 3 | 1 | R | TF01 | 0 | 27 | 0 |
| DD | 0964 | 3837 | 3 | 3890 | 54 | 52 | 2 | 1 | S | TF01 | 0 | 90 | 0 |
| DD | 0964 | 4099 | 3 | 4130 | 32 | 0 | 32 | 1 | T | TF01 | 0 | 209 | 0 |
| DD | 0964 | 4270 | 3 | 4272 | 3 | 0 | 3 | 1 | S | TF01 | 0 | 140 | 0 |
| DD | 0964 | 3516 | 3 | 3530 | 15 | 10 | 5 | 1 | S | TF03 | 0 | 0 | 0 |
| DD | 0964 | 3541 | 3 | 3545 | 5 | 0 | 5 | 1 | T | TF03 | 0 | 11 | 0 |
| DD | 0964 | 3623 | 3 | 3671 | 49 | 43 | 6 | 1 | S | TF03 | 0 | 78 | 0 |
| DD | 0964 | 3741 | 3 | 3762 | 22 | 17 | 5 | 1 | S | TF03 | 0 | 69 | 0 |
| DD | 0964 | 3776 | 3 | 3892 | 117 | 67 | 50 | 1 | S | TF03 | 0 | 14 | 0 |
| DD | 0964 | 4838 | 3 | 4838 | 1 | 0 | 1 | 0 | S | TF03 | 0 | 919 | 0 |
| DD | 0964 | 3656 | 3 | 3727 | 72 | 7 | 65 | 1 | T | T405 | 0 | 0 | 0 |
| DD | 0964 | 3237 | 3 | 3300 | 64 | 0 | 64 | 1 | R | T408 | 0 | 0 | 0 |
| DD | 0964 | 3987 | 3 | 4109 | 123 | 0 | 123 | 1 | R | T408 | 0 | 687 | 0 |
| DD | 0964 | 4209 | 3 | 4270 | 62 | 0 | 62 | 1 | T | T408 | 0 | 100 | 0 |
| DD | 0964 | 4582 | 3 | 4606 | 25 | 0 | 25 | 1 | S | T408 | 0 | 179 | 0 |
| DD | 0964 | 3811 | 3 | 3814 | 4 | 2 | 2 | 1 | S | T504 | 0 | 0 | 0 |
| DD | 0964 | 3588 | 3 | 3610 | 23 | 21 | 2 | 1 | S | T708 | 0 | 0 | 0 |
| DD | 0964 | 3213 | 3 | 3242 | 30 | 0 | 30 | 1 | R | 4708 | 0 | 0 | 0 |

# APPENDIX E
# SUMMED FAILURE RATE PROGRAMS

## 1. ALL UNITS INCLUDED IN CONTROL GROUP

This program uses all ships of intrest when generating control group failure rates.

```
//DATA   JOB (2908,9999),'FAILURE RATE',CLASS=G
//  EXEC FORTVCLG,REGION.GO=1500K
//FORT.SYSIN DD *
      PARAMETER (NEIC=111,NSHIP=700,NCS=900,NCL=22)
      CHARACTER*1  B2,REP(NCS)
      CHARACTER*2 B1
      CHARACTER*4 EICTBL(NEIC),CEIC(NCS)
      CHARACTER*5 A1
      CHARACTER*6 D1,E1
      CHARACTER*8 UCNAME(1351),C2,CRSTBL(NEIC),SHIP(NSHIP),USHIP(1351),
     .CSHIP(500),CLASS(NCL+1)
      CHARACTER*10 C1
      INTEGER UDATE(1351),CBDATE(NCS),
     .FLT(NCS),CEDATE(NCS),TDOWN(NCS),SDOWN(NCS),MDOWN(NCS),CENSOR(NCS)
      INTEGER ICOUNT(2,NEIC),ITIME(2,NEIC),ITRAIN
     .(NEIC),LUDATE(NEIC),ITOTAL(2,NEIC),ITOTTM(2,NEIC)
      DATA EICTBL/'TF01','TF03','TF04','CC01','CC03','EB03','KF01',
     .'KF03','TLOF','TLOG','TLOH','TLOJ','LBOM','LBON','LBOP','LBOQ',
     .'K703','K705','F703','F705','4708','4704','4703','F301','F303',
     .'F308','F309','F30A','F30C','F30D','F30E','F30G','F30H','FB01',
     .'FB05','FB06','FB07','E901','E905','E907','E909','K301','K303',
     .'K308','K309','K30A','K30C','K30D','K30E','K30G','K30H','KA01',
     .'KA05','KA06','KA07','T707','T708','T401','T403','T404','T405',
     .'T406','T407','T408','T409','T40S','T40T','T501','T504','N401',
     .'N403','N404','N405','N406','N407','N408','N409','N40A','N40B',
     .'N40C','N40D','N40E','N40F','N40G','N40H','N40J','N40K','N40L',
     .'N40M','N40N','N40P','N40Q','N40R','N40S','N40T','N40U','N40V',
     .'N40W','N40X','T901','T903','T904','T405','T906','T907','T908',
     .'T909','T911','T90A','T90C','    '/
      DATA CRSTBL/ 2*'AIR COMP',1*'DRY AIR',9*'ELEC MOT',4*'MK 19   ',
     . 4*'STEAMVAL',1*'60/400HZ',2*'60/400MG',34*'CENTPUMP',
     .12*'AC&R    ',30*'DE      ',11*'FIRE    ','        '/
      DATA CLASS/'AD      ','AE      ','AO      ','AOR     ','AR      ',
     .,'CG      ','CGN     ','CV      ','DD      ','DD  0963',
     .'DDG     ','DDG 0993','FF      ','FF  1052','FFG     ',
     .'FFG 0007','LCC     ','LHA     ','LPD     ','LPH     ',
     .'LSD     ','LST     ','ZZZZZZZZ'/
C
    2 FORMAT(A2,A8,A1,A8,A8,I5)
    4 FORMAT(A5,A8,A10,I5,I1,A6,I5,I4,I4,I4,I1,A6,A1,A4)
    6 FORMAT(1X,'JSHIP',1X,'   SHIP   ','NCASRP')
    7 FORMAT(1X,I4,2X,A8,2X,I4,2(2X,I5))
    8 FORMAT(1X,A8,2(1X,I5,1X,I7,1X,F8.6),1X,A4,1X,A8)
    9 FORMAT(2X,A8,2X,I4,4X,I4,2X,F12.6,2X,4X,I4,2X,I4,2X,F12.6,1X,A4,
     .2X,I5)
   10 FORMAT(2X,A8,2X,A8,2X,I5)
   11 FORMAT(2X,A8,2X,I3,2X,A4,2X,A8,6(2X,I5))
C     READ UNIFIED DATA
      JSHIP=0
      LSHIP=0
      DO 100 I=1,1351
      READ(1,2,END=110)B1,USHIP(I),B2,UCNAME(I),C2,UDATE(I)
C     TEST FOR NEW SHIP
      DO 15 J=1,NSHIP
      IF(SHIP(J).EQ.USHIP(I))THEN
         JJ=J
         GO TO 20
```

```
      ENDIF
   15 CONTINUE
C     NEW SHIP
      JSHIP=JSHIP+1
      IF (JSHIP.GT.NSHIP)STOP 'JSHIP.GT.NSHIP'
      JJ=JSHIP
      SHIP(JSHIP)=USHIP(I)
   20 CONTINUE
  100 CONTINUE
  110 CONTINUE
C     READ CASREP FILE AND PROCESS DATA FOR ONE SHIP AT A TIME
      NCLASS=1
      DO 150 J=1,NEIC
      ITRAIN(J)=1
      LUDATE(J)=0
      ICOUNT(1,J)=0
      ICOUNT(2,J)=0
      ITIME(1,J)=0
      ITIME(2,J)=0
      ITOTAL(1,J)=0
      ITOTAL(2,J)=0
      ITOTTM(1,J)=0
      ITOTTM(2,J)=0
  150 CONTINUE
      IUDATE=0
      JSHIP=0
      I=0
      DO 1000 K=1,90000
  200 CONTINUE
      I=I+1
      READ(2,4,END=280)A1,CSHIP(I),C1,CBDATE(I),FLT(I),D1,CEDATE(I)
     .,TDOWN(I),SDOWN(I),MDOWN(I),CENSOR(I),E1,REP(I),CEIC(I)
  250 CONTINUE
      IF(I.EQ.1) THEN
         C2=CSHIP(I)
      ELSE
         IF(CSHIP(I).NE.C2) GO TO 300
      ENDIF
      GO TO 200
  280 CONTINUE
      LSHIP=1
  300 CONTINUE
      NCASRP=I-1
      IF (NCASRP.GT.NCS) STOP 'NCASRP.GT.NCS'
      DO 500 J=1,NSHIP
      IF(C2.EQ.SHIP(J)) THEN
         JSHIP=J
         GO TO 510
      ENDIF
  500 CONTINUE
  510 CONTINUE
      DO 740 N=1,NCASRP
      IUDATE=0
      MTBF=0
      JEIC=NEIC
      JDUM=0
      IF (N.EQ.1) GO TO 590
      DO 580 NN=1,N-1
      IF (CEIC(NN).EQ.CEIC(N)) THEN
         MTBF=CBDATE(N)-CEDATE(NN)
      END IF
  580 CONTINUE
  590 CONTINUE
      DO 600 J=1,NEIC-1
      IF(CEIC(N).EQ.EICTBL(J)) THEN
         JEIC=J
         GO TO 610
      ENDIF
  600 CONTINUE
  610 CONTINUE
```

```
      IF(N.EQ.1.OR.LUDATE(JEIC).EQ.0)GOTO 700
      IF((CBDATE(N)-LUDATE(JEIC)).GT.1095)THEN
         ITRAIN(JEIC)=1
      ENDIF
  700 CONTINUE
      IF(JSHIP.EQ.0)GOTO 730
      DO 720 I=1,1351
      IF (C2.EQ.USHIP(I).AND.CRSTBL(JEIC).EQ.UCNAME(I).AND.(CBDATE(N)-
     .UDATE(I)).GE.0.AND.(CBDATE(N)-UDATE(I)).LE.1095) THEN
         IUDATE=UDATE(I)
         ITRAIN(JEIC)=2
         LUDATE(JEIC)=IUDATE
         JDUM=1
         GO TO 730
      END IF
  720 CONTINUE
  730 CONTINUE
C     INCREMENT COUNTER
      ICOUNT(ITRAIN(JEIC),JEIC)=ICOUNT(ITRAIN(JEIC),JEIC)+1
  740 CONTINUE
C     END OF CASREPS
C     TIME INCREMENT
      DO 770 JEIC=1,NEIC
      LUDATE(JEIC)=0
      ITRAIN(JEIC)=1
      DO 750 I=1,1351
      IF(UDATE(I).GT.4840)GO TO 750
      IF(C2.EQ.USHIP(I).AND.CRSTBL(JEIC).EQ.UCNAME(I).AND.UDATE(I).GT.
     .LUDATE(JEIC))THEN
         IF((UDATE(I)-LUDATE(JEIC)).LT.1095)THEN
            ITIME(2,JEIC)=ITIME(2,JEIC)+UDATE(I)-LUDATE(JEIC)
         ELSE
            ITIME(2,JEIC)=ITIME(2,JEIC)+1095
         ENDIF
         LUDATE(JEIC)=UDATE(I)
         ITRAIN(JEIC)=2
         ITIME(1,JEIC)=MAX0(ITIME(1,JEIC),(4840-UDATE(I)))
      ENDIF
  750 CONTINUE
  760 CONTINUE
      IF(ITRAIN(JEIC).EQ.2.AND.(4840-LUDATE(JEIC)).LT.1095)THEN
            ITIME(2,JEIC)=ITIME(2,JEIC)+4840-LUDATE(JEIC)-1095
      ENDIF
      ITIME(1,JEIC)=MAX0(ITIME(1,JEIC),(4840-CBDATE(1)))-ITIME(2,JEIC)
  770 CONTINUE
      DO 780 J=1,NEIC
      IF(ITIME(1,J).GT.0) THEN
         FAIL1=FLOAT(ICOUNT(1,J))/FLOAT(ITIME(1,J))
      ELSE
         FAIL1=0.
      ENDIF
      IF(ITIME(2,J).GT.0) THEN
         FAIL2=FLOAT(ICOUNT(2,J))/FLOAT(ITIME(2,J))
      ELSE
         FAIL2=0.
      ENDIF
      IF(ITIME(2,J).EQ.0)GO TO 780
      ITOTAL(1,J)=ITOTAL(1,J)+ICOUNT(1,J)
      ITOTAL(2,J)=ITOTAL(2,J)+ICOUNT(2,J)
      ITOTTM(1,J)=ITOTTM(1,J)+ITIME(1,J)
      ITOTTM(2,J)=ITOTTM(2,J)+ITIME(2,J)
  780 CONTINUE
  790 CONTINUE
C     END CLASS
      IF(LSHIP.EQ.1.OR.LGE(CSHIP(NCASRP+1),CLASS(NCLASS+1)))THEN
         DO 795 J=1,NEIC
         IF(ITOTTM(1,J).GT.0)THEN
            FAIL1=FLOAT(ITOTAL(1,J))/FLOAT(ITOTTM(1,J))
         ELSE
            FAIL1=0.
```

```
          ENDIF
          IF(ITOTTM(2,J).GT.0)THEN
             FAIL2=FLOAT(ITOTAL(2,J))/FLOAT(ITOTTM(2,J))
          ELSE
             FAIL2=0.
          ENDIF
          IF((ITOTAL(1,J)+ITOTAL(2,J)+ITOTTM(2,J)).GT.0)
     .    WRITE(6,8)CLASS(NCLASS),ITOTAL(1,J),ITOTTM(1,J),FAIL1,ITOTAL(2,
     .    J),ITOTTM(2,J),FAIL2,EICTBL(J),CRSTBL(J)
C         NEW CLASS
          ITOTAL(1,J)=0
          ITOTAL(2,J)=0
          ITOTTM(1,J)=0
          ITOTTM(2,J)=0
  795     CONTINUE
          IF(LSHIP.EQ.1)GOTO 1100
          NCLASS=NCLASS+1
          IF(NCLASS.GT.NCL)STOP 'NCLASS.GT.NCL'
      ENDIF
C     START NEW SHIP
      DO 800 J=1,NEIC
      ITRAIN(J)=1
      LUDATE(J)=0
      ICOUNT(1,J)=0
      ICOUNT(2,J)=0
      ITIME(1,J)=0
      ITIME(2,J)=0
  800 CONTINUE
      IUDATE=0
      I=1
      JSHIP=0
      CSHIP(I)=CSHIP(NCASRP+1)
      CBDATE(I)=CBDATE(NCASRP+1)
      FLT(I)=FLT(NCASRP+1)
      CEDATE(I)=CEDATE(NCASRP+1)
      TDOWN(I)=TDOWN(NCASRP+1)
      SDOWN(I)=SDOWN(NCASRP+1)
      MDOWN(I)=MDOWN(NCASRP+1)
      CENSOR(I)=CENSOR(NCASRP+1)
      REP(I)=REP(NCASRP+1)
      CEIC(I)=CEIC(NCASRP+1)
      GO TO 250
 1000 CONTINUE
 1100 CONTINUE
      STOP
      END
/*
//GO.FT01F001 DD DISP=SHR,
//   DSN=MSS.S2908.SUBSET.UNIFIED2
//GO.FT02F001 DD DISP=(OLD,KEEP),
//   DSN=MSS.S2908.SUBSET.CASREPT
```

## 2. TRAINED UNITS ONLY IN CONTROL GROUP

This program is used to examine the OMT effect by comparing failure rates for units which receive training. Equipment time and failure counters in this program record only ships of interest wh[illegible] participated in the training program.

```
//T365T   JOB (2908,9999),'EIC FORTRAN',CLASS=G
//  EXEC FORTVCLG,REGION.GO=1500K
//FORT.SYSIN DD *
      PARAMETER (NEIC=111,NSHIP=700,NCS=900,NCL=22)
      CHARACTER*1  B2,REP(NCS)
      CHARACTER*2 B1
      CHARACTER*4 EICTBL(NEIC),CEIC(NCS)
      CHARACTER*5 A1
      CHARACTER*6 D1,E1
```

```
      CHARACTER*8 UCNAME(1351),C2,CRSTBL(NEIC),SHIP(NSHIP),USHIP(1351),
     .CSHIP(500),CLASS(NCL+1)
      CHARACTER*10 C1
      INTEGER UDATE(1351),CBDATE(NCS),
     .FLT(NCS),CEDATE(NCS),TDOWN(NCS),SDOWN(NCS),MDOWN(NCS),CENSOR(NCS)
      INTEGER ICOUNT(2,NEIC),ITIME(2,NEIC),ITRAIN
     .(NEIC),LUDATE(NEIC),ITOTAL(2,NEIC),ITOTTM(2,NEIC)
      DATA EICTBL/'TF01','TF03','TF04','CC01','CC03','EB03','KF01',
     .'KF03','TL0F','TL0G','TL0H','TL0J','LB0M','LB0N','LB0P','LB0Q',
     .'K703','K705','F703','F705','4708','4704','4703','F301','F303',
     .'F308','F309','F30A','F30C','F30D','F30E','F30G','F30H','FB01',
     .'FB05','FB06','FB07','E901','E905','E907','E909','K301','K303',
     .'K308','K309','K30A','K30C','K30D','K30E','K30G','K30H','KA01',
     .'KA05','KA06','KA07','T707','T708','T401','T403','T404','T405',
     .'T406','T407','T408','T409','T40S','T40T','T501','T504','N401',
     .'N403','N404','N405','N406','N407','N408','N409','N40A','N40B',
     .'N40C','N40D','N40E','N40F','N40G','N40H','N40J','N40K','N40L',
     .'N40M','N40N','N40P','N40Q','N40R','N40S','N40T','N40U','N40V',
     .'N40W','N40X','T901','T903','T904','T405','T906','T907','T908',
     .'T909','T911','T90A','T90C','    '/
      DATA CRSTBL/ 2*'AIR COMP',1*'DRY AIR',9*'ELEC MOT',4*'MK 19   ',
     . 4*'STEAMVAL',1*'60/400HZ',2*'60/400MG',34*'CENTPUMP',
     .12*'AC&R    ',30*'DE      ',11*'FIRE    ','        '/
      DATA CLASS/'AD      ','AE      ','AO      ','AOR     ','AR      '
     .,'CG      ','CGN     ','CV      ','DD      ','DD  0963',
     .'DDG     ','DDG 0993','FF      ','FF  1052','FFG     ',
     .'FFG 0007','LCC     ','LHA     ','LPD     ','LPH     ',
     .'LSD     ','LST     ','ZZZZZZZZ'/
C
    2 FORMAT(A2,A8,A1,A8,A8,I5)
    4 FORMAT(A5,A8,A10,I5,I1,A6,I5,I4,I4,I4,I1,A6,A1,A4)
    6 FORMAT(1X,'JSHIP',1X,'  SHIP  ','NCASRP')
    7 FORMAT(1X,I4,2X,A8,2X,I4,2(2X,I5))
    8 FORMAT(1X,A8,2(1X,I5,1X,I7,1X,F8.6),1X,A4,1X,A8)
    9 FORMAT(2X,A8,2X,I4,4X,I4,2X,F12.6,2X,4X,I4,2X,I4,2X,F12.6,1X,A4,
     .2X,I5)
   10 FORMAT(2X,A8,2X,A8,2X,I5)
   11 FORMAT(2X,A8,2X,I3,2X,A4,2X,A8,6(2X,I5))
C     READ UNIFIED DATA
      JSHIP=0
      LSHIP=0
      DO 100 I=1,1351
      READ(1,2,END=110)B1,USHIP(I),B2,UCNAME(I),C2,UDATE(I)
C     TEST FOR NEW SHIP
      DO 15 J=1,NSHIP
      IF(SHIP(J).EQ.USHIP(I))THEN
         JJ=J
         GO TO 20
      ENDIF
   15 CONTINUE
C     NEW SHIP
      JSHIP=JSHIP+1
      IF (JSHIP.GT.NSHIP)STOP 'JSHIP.GT.NSHIP'
      JJ=JSHIP
      SHIP(JSHIP)=USHIP(I)
   20 CONTINUE
  100 CONTINUE
  110 CONTINUE
C     READ CASREP FILE AND PROCESS DATA FOR ONE SHIP AT A TIME
      NCLASS=1
      DO 150 J=1,NEIC
      ITRAIN(J)=1
      LUDATE(J)=0
      ICOUNT(1,J)=0
      ICOUNT(2,J)=0
      ITIME(1,J)=0
      ITIME(2,J)=0
      ITOTAL(1,J)=0
      ITOTAL(2,J)=0
      ITOTTM(1,J)=0
```

```
      ITOTTM(2,J)=0
  150 CONTINUE
      IUDATE=0
      JSHIP=0
      I=0
      DO 1000 K=1,90000
  200 CONTINUE
      I=I+1
      READ(2,4,END=280)A1,CSHIP(I),C1,CBDATE(I),FLT(I),D1,CEDATE(I)
     .,TDOWN(I),SDOWN(I),MDOWN(I),CENSOR(I).E1,REP(I),CEIC(I)
  250 CONTINUE
      IF(I.EQ.1) THEN
         C2=CSHIP(I)
      ELSE
         IF(CSHIP(I).NE.C2) GO TO 300
      ENDIF
      GO TO 200
  280 CONTINUE
      LSHIP=1
  300 CONTINUE
      NCASRP=I-1
      IF (NCASRP.GT.NCS) STOP 'NCASRP.GT.NCS'
      DO 500 J=1,NSHIP
      IF(C2.EQ.SHIP(J)) THEN
         JSHIP=J
         GO TO 510
      ENDIF
  500 CONTINUE
  510 CONTINUE
      DO 740 N=1,NCASRP
      IUDATE=0
      MTBF=0
      JEIC=NEIC
      JDUM=0
      IF (N.EQ.1) GO TO 590
      DO 580 NN=1,N-1
      IF (CEIC(NN).EQ.CEIC(N)) THEN
         MTBF=CBDATE(N)-CEDATE(NN)
      END IF
  580 CONTINUE
  590 CONTINUE
      DO 600 J=1,NEIC-1
      IF(CEIC(N).EQ.EICTBL(J)) THEN
         JEIC=J
         GO TO 610
      ENDIF
  600 CONTINUE
  610 CONTINUE
      IF(N.EQ.1.OR.LUDATE(JEIC).EQ.0)GOTO 700
      IF((CEDATE(N)-LUDATE(JEIC)).GT.365)THEN
         ITRAIN(JEIC)=1
      ENDIF
  700 CONTINUE
C     SKIP SHIPS WITH NO TRAINING
      IF(JSHIP.EQ.0)GOTO 730
      DO 720 I=1,1351
      IF (C2.EQ.USHIP(I).AND.CRSTBL(JEIC).EQ.UCNAME(I).AND.(CBDATE(N)-
     .UDATE(I)).GE.0.AND.(CBDATE(N)-UDATE(I)).LE.365) THEN
         IUDATE=UDATE(I)
         ITRAIN(JEIC)=2
         LUDATE(JEIC)=IUDATE
         JDUM=1
         GO TO 730
      END IF
  720 CONTINUE
  730 CONTINUE
C     INCREMENT COUNTER
      ICOUNT(ITRAIN(JEIC),JEIC)=ICOUNT(ITRAIN(JEIC),JEIC)+1
  740 CONTINUE
C     END OF CASREPS
```

```
C     TIME INCREMENT
      DO 770 JEIC=1,NEIC
      LUDATE(JEIC)=0
      ITRAIN(JEIC)=1
      DO 750 I=1,1351
      IF(UDATE(I).GT.4840)GO TO 750
      IF(C2.EQ.USHIP(I).AND.CRSTBL(JEIC).EQ.UCNAME(I).AND.UDATE(I).GT.
     .LUDATE(JEIC))THEN
         IF((UDATE(I)-LUDATE(JEIC)).LT.365)THEN
            ITIME(2,JEIC)=ITIME(2,JEIC)+UDATE(I)-LUDATE(JEIC)
         ELSE
            ITIME(2,JEIC)=ITIME(2,JEIC)+365
         ENDIF
         LUDATE(JEIC)=UDATE(I)
         ITRAIN(JEIC)=2
         ITIME(1,JEIC)=MAX0(ITIME(1,JEIC),(4840-UDATE(I)))
      ENDIF
  750 CONTINUE
  760 CONTINUE
      IF(ITRAIN(JEIC).EQ.2.AND.(4840-LUDATE(JEIC)).LT.365)THEN
            ITIME(2,JEIC)=ITIME(2,JEIC)+4840-LUDATE(JEIC)-365
      ENDIF
      ITIME(1,JEIC)=MAX0(ITIME(1,JEIC),(4840-CBDATE(1)))-ITIME(2,JEIC)
  770 CONTINUE
      DO 780 J=1,NEIC
      IF(ITIME(1,J).GT.0) THEN
         FAIL1=FLOAT(ICOUNT(1,J))/FLOAT(ITIME(1,J))
      ELSE
         FAIL1=0.
      ENDIF
      IF(ITIME(2,J).GT.0) THEN
         FAIL2=FLOAT(ICOUNT(2,J))/FLOAT(ITIME(2,J))
      ELSE
         FAIL2=0.
      ENDIF
      IF(ITIME(2,J).EQ.0)GO TO 780
      ITOTAL(1,J)=ITOTAL(1,J)+ICOUNT(1,J)
      ITOTAL(2,J)=ITOTAL(2,J)+ICOUNT(2,J)
      ITOTTM(1,J)=ITOTTM(1,J)+ITIME(1,J)
      ITOTTM(2,J)=ITOTTM(2,J)+ITIME(2,J)
  780 CONTINUE
  790 CONTINUE
C     END CLASS
      IF(LSHIP.EQ.1.OR.LGE(CSHIP(NCASRP+1),CLASS(NCLASS+1)))THEN
         DO 795 J=1,NEIC
         IF(ITOTTM(1,J).GT.0)THEN
            FAIL1=FLOAT(ITOTAL(1,J))/FLOAT(ITOTTM(1,J))
         ELSE
            FAIL1=0.
         ENDIF
         IF(ITOTTM(2,J).GT.0)THEN
            FAIL2=FLOAT(ITOTAL(2,J))/FLOAT(ITOTTM(2,J))
         ELSE
            FAIL2=0.
         ENDIF
         IF((ITOTAL(1,J)+ITOTAL(2,J)+ITOTTM(2,J)).GT.0)
     .   WRITE(6,8)CLASS(NCLASS),ITOTAL(1,J),ITOTTM(1,J),FAIL1,ITOTAL(2
     .   J),ITOTTM(2,J),FAIL2,EICTBL(J),CRSTBL(J)
C        NEW CLASS
         ITOTAL(1,J)=0
         ITOTAL(2,J)=0
         ITOTTM(1,J)=0
         ITOTTM(2,J)=0
  795    CONTINUE
         IF(LSHIP.EQ.1)GOTO 1100
         NCLASS=NCLASS+1
         IF(NCLASS.GT.NCL)STOP 'NCLASS.GT.NCL'
      ENDIF
C     START NEW SHIP
      DO 800 J=1,NEIC
```

```
      ITRAIN(J)=1
      LUDATE(J)=0
      ICOUNT(1,J)=0
      ICOUNT(2,J)=0
      ITIME(1,J)=0
      ITIME(2,J)=0
  800 CONTINUE
      IUDATE=0
      I=1
      JSHIP=0
      CSHIP(I)=CSHIP(NCASRP+1)
      CBDATE(I)=CBDATE(NCASRP+1)
      FLT(I)=FLT(NCASRP+1)
      CEDATE(I)=CEDATE(NCASRP+1)
      TDOWN(I)=TDOWN(NCASRP+1)
      SDOWN(I)=SDOWN(NCASRP+1)
      MDOWN(I)=MDOWN(NCASRP+1)
      CENSOR(I)=CENSOR(NCASRP+1)
      REP(I)=REP(NCASRP+1)
      CEIC(I)=CEIC(NCASRP+1)
      GO TO 250
 1000 CONTINUE
 1100 CONTINUE
      STOP
      END
/*
//GO.FT01F001 DD DISP=SHR,
//    DSN=MSS.S2908.SUBSET.UNIFIED2
//GO.FT02F001 DD DISP=(OLD,KEEP),
//    DSN=MSS.S2908.SUBSET.CASREPT
//GO.FT03F001 DD DISP=(OLD,KEEP),SPACE=(19032,(304,10)),
//    DCB=(RECFM=FB,LRECL=78,BLKSIZE=19032),
//    UNIT=SYSDA,
//    DSN=MSS.S2908.FAILRATE
```

## 3. EXAMPLE OF SUMMED FAILURE RATE FILE

The following is an example of the output of the failure rate program. The relationship between EICs and OMT courses exist in the last two columns.

```
DD  0963   169   35018 0.004826    33   12219 0.002701 TF01 AIR COMP
DD  0963   106   35018 0.003027    23   12219 0.001882 TF03 AIR COMP
DD  0963    18   30467 0.000591    10   16549 0.000604 TF04 DRY AIR
DD  0963     0   29036 0.000000     0   19860 0.000000 CC01 ELEC MOT
DD  0963     0   29036 0.000000     1   19860 0.000050 CC03 ELEC MOT
DD  0963     0   29036 0.000000     1   19860 0.000050 EB03 ELEC MOT
DD  0963     0   29036 0.000000     0   19860 0.000000 KF01 ELEC MOT
DD  0963     0   29036 0.000000     0   19860 0.000000 KF03 ELEC MOT
DD  0963     0   29036 0.000000     0   19860 0.000000 TL0F ELEC MOT
DD  0963     0   29036 0.000000     0   19860 0.000000 TL0G ELEC MOT
DD  0963     0   29036 0.000000     0   19860 0.000000 TL0H ELEC MOT
DD  0963     0   29036 0.000000     0   19860 0.000000 TL0J ELEC MOT
DD  0963     3   47016 0.000064     0       0 0.000000 LB0M MK 19
DD  0963     2   47016 0.000043     0       0 0.000000 LB0Q MK 19
DD  0963     0   34231 0.000000     0   13866 0.000000 K703 STEAMVAL
DD  0963     0   34231 0.000000     0   13866 0.000000 K705 STEAMVAL
DD  0963     0   34231 0.000000     0   13866 0.000000 F703 STEAMVAL
DD  0963     0   34231 0.000000     0   13866 0.000000 F705 STEAMVAL
DD  0963    33   35481 0.000930    11   12045 0.000913 4708 60/400HZ
DD  0963    11   47016 0.000234     0       0 0.000000 4703 60/400MG
DD  0963     1   35417 0.000028     0   12669 0.000000 F301 CENTPUMP
DD  0963     0   35417 0.000000     0   12669 0.000000 F303 CENTPUMP
DD  0963     0   35417 0.000000     0   12669 0.000000 F308 CENTPUMP
DD  0963     0   35417 0.000000     0   12669 0.000000 F309 CENTPUMP
DD  0963     0   35417 0.000000     0   12669 0.000000 F30A CENTPUMP
DD  0963     0   35417 0.000000     0   12669 0.000000 F30C CENTPUMP
DD  0963     0   35417 0.000000     0   12669 0.000000 F30D CENTPUMP
DD  0963     0   35417 0.000000     0   12669 0.000000 F30E CENTPUMP
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | F30G | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | F30H | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | FB01 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | FB05 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | FB06 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | FB07 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | E901 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 1 | 12669 | 0.000079 | E905 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | E907 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | E909 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | K301 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | K303 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | K308 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | K309 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | K30A | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | K30C | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | K30D | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | K30E | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | K30G | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | K30H | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | KA01 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | KA05 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | KA06 | CENTPUMP |
| DD | 0963 | 0 | 35417 | 0.000000 | 0 | 12669 | 0.000000 | KA07 | CENTPUMP |
| DD | 0963 | 6 | 35417 | 0.000169 | 3 | 12669 | 0.000237 | T707 | CENTPUMP |
| DD | 0963 | 8 | 35417 | 0.000226 | 0 | 12669 | 0.000000 | T708 | CENTPUMP |
| DD | 0963 | 0 | 31782 | 0.000000 | 0 | 16135 | 0.000000 | T401 | AC&R |
| DD | 0963 | 1 | 31782 | 0.000031 | 1 | 16135 | 0.000062 | T403 | AC&R |
| DD | 0963 | 1 | 31782 | 0.000031 | 1 | 16135 | 0.000062 | T404 | AC&R |
| DD | 0963 | 29 | 31782 | 0.000912 | 3 | 16135 | 0.000186 | T405 | AC&R |
| DD | 0963 | 1 | 31782 | 0.000031 | 0 | 16135 | 0.000000 | T406 | AC&R |
| DD | 0963 | 0 | 31782 | 0.000000 | 0 | 16135 | 0.000000 | T407 | AC&R |
| DD | 0963 | 9 | 31782 | 0.000283 | 1 | 16135 | 0.000062 | T408 | AC&R |
| DD | 0963 | 0 | 31782 | 0.000000 | 2 | 16135 | 0.000124 | T409 | AC&R |
| DD | 0963 | 19 | 31782 | 0.000598 | 11 | 16135 | 0.000682 | T40S | AC&R |
| DD | 0963 | 0 | 31782 | 0.000000 | 0 | 16135 | 0.000000 | T40T | AC&R |
| DD | 0963 | 0 | 31782 | 0.000000 | 2 | 16135 | 0.000124 | T501 | AC&R |
| DD | 0963 | 3 | 31782 | 0.000094 | 1 | 16135 | 0.000062 | T504 | AC&R |
| DD | 0963 | 1 | 47016 | 0.000021 | 0 | 0 | 0.000000 | N401 | DE |
| DD | 0963 | 2 | 47016 | 0.000043 | 0 | 0 | 0.000000 | N405 | DE |
| DD | 0963 | 1 | 47016 | 0.000021 | 0 | 0 | 0.000000 | N406 | DE |
| DD | 0963 | 1 | 47016 | 0.000021 | 0 | 0 | 0.000000 | N40R | DE |
| DD | 0963 | 3 | 47016 | 0.000064 | 0 | 0 | 0.000000 | N40S | DE |
| DD | 0963 | 3 | 47016 | 0.000064 | 0 | 0 | 0.000000 | N40T | DE |
| DD | 0963 | 5 | 47016 | 0.000106 | 0 | 0 | 0.000000 | N40U | DE |
| DD | 0963 | 2 | 41320 | 0.000048 | 0 | 5696 | 0.000000 | T901 | FIRE |
| DD | 0963 | 16 | 41320 | 0.000387 | 0 | 5696 | 0.000000 | T903 | FIRE |
| DD | 0963 | 0 | 41320 | 0.000000 | 0 | 5696 | 0.000000 | T904 | FIRE |
| DD | 0963 | 0 | 41320 | 0.000000 | 0 | 5696 | 0.000000 | T405 | FIRE |
| DD | 0963 | 3 | 41320 | 0.000073 | 0 | 5696 | 0.000000 | T906 | FIRE |
| DD | 0963 | 0 | 41320 | 0.000000 | 0 | 5696 | 0.000000 | T907 | FIRE |
| DD | 0963 | 0 | 41320 | 0.000000 | 0 | 5696 | 0.000000 | T908 | FIRE |
| DD | 0963 | 0 | 41320 | 0.000000 | 0 | 5696 | 0.000000 | T909 | FIRE |
| DD | 0963 | 0 | 41320 | 0.000000 | 0 | 5696 | 0.000000 | T911 | FIRE |
| DD | 0963 | 0 | 41320 | 0.000000 | 0 | 5696 | 0.000000 | T90A | FIRE |
| DD | 0963 | 0 | 41320 | 0.000000 | 0 | 5696 | 0.000000 | T90C | FIRE |

# APPENDIX F
# SPSSX AND SAS PROGRAMS USED IN ANALYSIS OF FAILURE RATES

## 1. SPSSX PROGRAM

The following program produces aggregate failure rates, sample size, F statistic, and degrees of freedom.

```
TITLE UNIFIED TRAINING CLASS TEST
FILE HANDLE THESIS/ NAME = 'THESIS DATA A1'
DATA LIST FILE = THESIS/ CLASS 2-9(A) NTCASRP 11-15 NTTIME 17-23 NTFAIL
   25-32 TCASRP 34-38 TTIME 40-46 TFAIL 48-55 EIC 57-60(A)
   COURSE 62-69(A)
SELECT IF (NTCASRP GT 0 OR TCASRP GT 0)
AGGREGATE       OUTFILE = *
             / BREAK    = CLASS
             / NTREP NTTIM TREP TTIM = SUM(NTCASRP NTTIME TCASRP TTIME)
COMPUTE F=(((2*NTTIM)*(2*(1+TREP)))/((2*(1+NTREP))*(2*TTIM)))
COMPUTE N1=2*(1+NTREP)
COMPUTE N2=2*(1+TREP)
LIST
EXECUTE
FINISH
```

## 2. SAS PROGRAM

This SAS file uses the output of the SPSSx program above and computes a p-value from the F statictic and both degrees of freedom.

```
OPTIONS     LINESIZE=80;
DATA ONE;
     INPUT   COURSE $ 2-9 NTEP 12-18 NTTIM 20-27 TREP 31-36 TTIM 38-45
                F 51-54 N1 57-63 N2 66-72;
     PVALUE = 1 - PROBF(F,N1,N2);
     CARDS;
 AD            144.00 298317.0     31.00 42194.00       1.56     290.00     64.00
 AE            169.00 427438.0     46.00 141940.0        .83     340.00     94.00
 AO            102.00 164604.0     29.00 36616.00       1.31     206.00     60.00
 ACR           101.00 211353.0     28.00 61658.00        .97     204.00     58.00
 AR             32.00 55956.00     22.00 29310.00       1.33      66.00     46.00
 CG            563.00 765504.0    168.00 265391.0        .86    1128.00    338.00
 CGN           242.00 298079.0     18.00 53422.00        .44     486.00     38.00
 DD             90.00 214114.0      7.00 14668.00       1.28     182.00     16.00
 DD  0963      457.00  1215882    105.00 305731.0        .92     916.00    212.00
 DDG          1292.00  2019980    336.00 591734.0        .89    2586.00    674.00
 DDG 0993       78.00 99367.00     26.00 12629.00       2.69     158.00     54.00
 FF            309.00 426596.0    144.00 158296.0       1.26     620.00    290.00
 FF  1052     1119.00  2573314    234.00 533898.0       1.01    2240.00    470.00
 FFG           175.00 188311.0     25.00 31223.00        .89     352.00     52.00
 FFG 0007     1168.00 457729.0    113.00 25970.00       1.72    2338.00    228.00
 LCC            23.00 29404.00     16.00 11966.00       1.74      48.00     34.00
 LHA           127.00 159570.0     29.00 10708.00       3.49     256.00     60.00
 LPD           299.00 396566.0    175.00 224409.0       1.04     600.00    352.00
 LPH           207.00 243029.0     85.00 115003.0        .87     416.00    172.00
 LSD           191.00 455870.0     73.00 106840.0       1.64     384.00    148.00
 LST           216.00 510697.0     56.00 128517.0       1.04     434.00    114.00
PROC PRINT DATA=ONE;
     VAR      COURSE PVALUE F N1 N2;
```

## 3. SAS OUTPUT

The following is an example of the output from the preceeding SAS program. This output was used to produce the tabular displays of results throughout this thesis.

SAS

| OBS | COURSE | PVALUE | F | N1 | N2 |
|---|---|---|---|---|---|
| 1 | AD | 0.016842 | 1.56 | 290 | 64 |
| 2 | AE | 0.880972 | 0.83 | 340 | 94 |
| 3 | AO | 0.109704 | 1.31 | 206 | 60 |
| 4 | AOR | 0.572978 | 0.97 | 204 | 58 |
| 5 | AR | 0.154218 | 1.33 | 66 | 46 |
| 6 | CG | 0.960621 | 0.86 | 1128 | 338 |
| 7 | CGN | 0.999959 | 0.44 | 486 | 38 |
| 8 | DD | 0.294536 | 1.28 | 182 | 16 |
| 9 | DD 0963 | 0.788806 | 0.92 | 916 | 212 |
| 10 | DDG | 0.973720 | 0.89 | 2586 | 674 |
| 11 | DDG 0993 | 0.000030 | 2.69 | 158 | 54 |
| 12 | FF | 0.012228 | 1.26 | 620 | 290 |
| 13 | FF 1052 | 0.451105 | 1.01 | 2240 | 470 |
| 14 | FFG | 0.730289 | 0.89 | 352 | 52 |
| 15 | FFG 0007 | 0.000000 | 1.72 | 2338 | 228 |
| 16 | LCC | 0.046324 | 1.74 | 48 | 34 |
| 17 | LHA | 0.000000 | 3.49 | 256 | 60 |
| 18 | LPD | 0.343147 | 1.04 | 600 | 352 |
| 19 | LPH | 0.867186 | 0.87 | 416 | 172 |
| 20 | LSD | 0.000279 | 1.64 | 384 | 148 |
| 21 | LST | 0.407794 | 1.04 | 434 | 114 |

# APPENDIX G
# FURTHER TABULAR RESULTS

## 1. TRAINED UNITS ONLY IN CONTROL GROUP

TABLE 7

FAILURE RATES BY CLASS (TRAINED UNITS, 2 YEAR TIME HORIZON)

| *CLASS* | $\lambda_1 - \lambda_2$ | *PVALUE* |
|---|---|---|
| AD | .000606 | .93 |
| AE | .000298 | .99 |
| AO | .000167 | .66 |
| AOR | -.000192 | .11 |
| AR | .000569 | .95 |
| CG | .000088 | .83 |
| CGN | .000247 | .74 |
| DD | .000286 | .69 |
| DD 0963 | -.000121 | .02* |
| DDG | -.000029 | .32 |
| DDG 0993 | .000149 | .55 |
| FF | -.000269 | .04* |
| FF 1052 | -.000075 | .12 |
| FFG | -.000702 | .01* |
| FFG 0007 | .000070 | .53 |
| LCC | -.000574 | .22 |
| LHA | -.001200 | .04* |
| LPD | .000032 | .62 |
| LPH | .000125 | .76 |
| LSD | -.000060 | .35 |
| LST | .000121 | .84 |

$\lambda_1$ - Failure Rate w/o OMT

$\lambda_2$ - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

TABLE 8

FAILURE RATES BY CLASS (TRAINED UNITS, 1 YEAR TIME HORIZON)

| *CLASS* | | $\lambda_1 - \lambda_2$ | *PVALUE* |
|---|---|---|---|
| AD | | .000299 | .69 |
| AE | | .000254 | .98 |
| AO | | .000035 | .48 |
| AOR | | -.000327 | .02* |
| AR | | .000630 | .96 |
| CG | | .000082 | .77 |
| CGN | | .000156 | .60 |
| DD | | -.000517 | .13 |
| DD | 0963 | -.000198 | .00* |
| DDG | | -.000042 | .27 |
| DDG | 0993 | .000499 | .63 |
| FF | | -.000310 | .03* |
| FF | 1052 | -.000119 | .05* |
| FFG | | -.000035 | .42 |
| FFG | 0007 | .000488 | .67 |
| LCC | | -.001863 | .01* |
| LHA | | .000043 | .47 |
| LPD | | -.000062 | .29 |
| LPH | | -.000198 | .12 |
| LSD | | -.000182 | .13 |
| LST | | .000040 | .60 |

$\lambda_1$ - Failure Rate w/o OMT

$\lambda_2$ - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

TABLE 9

FAILURE RATES BY EIC (TRAINED UNITS, 3 YEAR TIME HORIZON)

| EIC | $\lambda_1-\lambda_2$ | PVALUE |
|---|---|---|
| CC03 | .000020 | .68 |
| EB03 | .000016 | .68 |
| E905 | -.000079 | .29 |
| FB01 | -.000222 | .02* |
| FB05 | .000102 | .83 |
| FB06 | .000014 | .67 |
| FB07 | .000199 | .85 |
| F30A | .000085 | .79 |
| F30D | .000479 | .97 |
| F30E | -.000016 | .53 |
| F30G | -.000028 | .48 |
| F30H | .000098 | .88 |
| F301 | .000037 | .76 |
| F303 | .000081 | .86 |
| F308 | .000009 | .66 |
| F309 | .000097 | .86 |
| F703 | -.000198 | .14 |
| F705 | .000027 | .68 |
| K703 | -.000068 | .47 |
| LB0M | .000178 | .79 |
| LB0N | -.000084 | .48 |
| LB0P | .000336 | .89 |
| LB0Q | .000530 | .97 |
| N40C | .000037 | .63 |
| N40D | .000259 | .77 |
| N40L | -.000084 | .36 |
| N40P | -.000860 | .19 |
| N40Q | -.000378 | .32 |
| N40R | -.000609 | .29 |
| N405 | .000815 | .91 |
| TF01 | .000601 | .99 |
| TF03 | .000439 | .98 |
| TF04 | -.000155 | .40 |
| T40S | -.000149 | .26 |
| T401 | .000119 | .96 |
| T403 | -.000079 | .31 |
| T404 | .000127 | .81 |
| T405 | .000212 | .99 |
| T406 | -.000007 | .56 |
| T407 | .001068 | .97 |
| T408 | .000183 | .93 |
| T409 | .000032 | .72 |
| T501 | -.000039 | .40 |
| T504 | -.000022 | .48 |
| T707 | .000150 | .99 |
| T708 | .000066 | .79 |
| T901 | .000325 | .99 |
| T903 | .000463 | .99 |
| T906 | .000201 | .86 |
| 4703 | -.000061 | .63 |
| 4704 | -.001094 | .19 |
| 4708 | .000971 | .97 |

* significant ($\alpha \leq .1$)

## 2. ALL SHIPS IN CONTROL GROUP

TABLE 10

FAILURE RATES BY CLASS (ALL UNITS, 2 YEAR TIME HORIZON)

| *CLASS* | | $\lambda_1 - \lambda_2$ | *PVALUE* |
|---|---|---|---|
| AD | | -.000131 | .15 |
| AE | | .000081 | .88 |
| AO | | -.000227 | .08 |
| AOR | | -.000089 | .18 |
| AR | | .000277 | .91 |
| CG | | .000066 | .84 |
| CGN | | .000371 | .99 |
| DD | | -.000268 | .07 |
| DD | 0963 | -.000051 | .11 |
| DDG | | .000033 | .78 |
| DDG | 0993 | -.001419 | .00* |
| FF | | -.000221 | .00* |
| FF | 1052 | -.000006 | .41 |
| FFG | | -.000034 | .38 |
| FFG | 0007 | -.001510 | .00* |
| LCC | | -.000730 | .02* |
| LHA | | -.002003 | .00* |
| LPD | | .000035 | .66 |
| LPH | | -.000009 | .44 |
| LSD | | -.000307 | .00 |
| LST | | -.000006 | .42 |

$\lambda_1$ - Failure Rate w/o OMT

$\lambda_2$ - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

TABLE 11

FAILURE RATES BY CLASS (ALL UNITS, 1 YEAR TIME HORIZON)

| *CLASS* | $\lambda_1-\lambda_2$ | *PVALUE* |
|---|---|---|
| AD | -.000190 | .12 |
| AE | .000114 | .90 |
| AO | -.000256 | .10 |
| AOR | -.000217 | .05* |
| AR | .000377 | .95 |
| CG | .000073 | .80 |
| CGN | .000350 | .96 |
| DD | -.000781 | .00* |
| DD 0963 | -.000124 | .01* |
| DDG | .000019 | .60 |
| DDG 0993 | -.001085 | .01* |
| FF | -.000284 | .00* |
| FF 1052 | -.000039 | .18 |
| FFG | .000190 | .70 |
| FFG 0007 | -.001137 | .01* |
| LCC | -.001584 | .00* |
| LHA | -.001215 | .00* |
| LPD | -.000025 | .38 |
| LPH | -.000213 | .04 |
| LSD | -.000395 | .00 |
| LST | -.000040 | .28 |

$\lambda_1$ - Failure Rate w/o OMT

$\lambda_2$ - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

TABLE 12

FAILURE RATES BY EIC (ALL UNITS, 3 YR HORIZON)

| *EIC* | *PVALUE* | $\lambda_1$ | $\lambda_2$ | $\lambda_1 - \lambda_2$ |
|---|---|---|---|---|
| CC03 | .45 | .000042 | .000041 | .000001 |
| EE03 | .24 | .000012 | .000025 | -.000013 |
| E905 | .06 | .000000 | .000079 | -.000079 |
| FB01 | .02* | .000262 | .000403 | -.000141 |
| FB05 | .20 | .000065 | .000093 | -.000028 |
| FB06 | .29 | .000063 | .000083 | -.000020 |
| FB07 | .63 | .000033 | .000000 | .000033 |
| F30A | .18 | .000064 | .000124 | -.000060 |
| F30D | .85 | .000235 | .000068 | .000166 |
| F30E | .37 | .000077 | .000083 | -.000006 |
| F30G | .50 | .000318 | .000313 | .000006 |
| F30H | .97 | .000549 | .000363 | .000186 |
| F301 | .26 | .000273 | .000312 | -.000038 |
| F303 | .62 | .003636 | .003543 | .000093 |
| F308 | .12 | .000466 | .000564 | -.000099 |
| F309 | .62 | .000845 | .000804 | .000040 |
| F703 | .02* | .000755 | .000963 | -.000209 |
| F705 | .35 | .000106 | .000119 | -.000013 |
| K703 | .24 | .000000 | .000068 | -.000068 |
| LB0M | .22 | .000152 | .000196 | -.000044 |
| LB0N | .00* | .000778 | .001689 | -.000911 |
| LB0P | .89 | .000258 | .000116 | .000143 |
| LB0Q | .99 | .000464 | .000133 | .000331 |
| N40C | .58 | .000129 | .000071 | .000058 |
| N40D | .55 | .001531 | .001461 | .000070 |
| N40E | .38 | .000023 | .000000 | .000023 |
| N40L | .48 | .000085 | .000055 | .000030 |
| N40M | .51 | .000049 | .000000 | .000049 |
| N40N | .38 | .000081 | .000000 | .000081 |
| N40P | .11 | .000761 | .001281 | -.000521 |
| N40Q | .22 | .000325 | .000378 | -.000052 |
| N40R | .10 | .000180 | .000337 | -.000157 |
| N40S | .40 | .000031 | .000000 | .000031 |
| N40T | .73 | .000136 | .000000 | .000136 |
| N40V | .65 | .000157 | .000000 | .000157 |
| N401 | .12 | .000037 | .000000 | .000037 |
| N405 | .69 | .000062 | .000000 | .000062 |
| N408 | .41 | .000033 | .000000 | .000033 |
| N409 | .22 | .000045 | .000000 | .000045 |
| TF01 | 1.00 | .002972 | .002172 | .000800 |
| TF03 | .99 | .002873 | .002422 | .000451 |
| TF04 | .46 | .000595 | .000574 | .000022 |
| T40S | .18 | .000500 | .000601 | -.000101 |
| T401 | .96 | .000129 | .000059 | .000070 |
| T403 | .74 | .000047 | .000025 | .000022 |
| T404 | .55 | .001574 | .001556 | .000019 |
| T405 | .98 | .000425 | .000267 | .000158 |
| T406 | .40 | .000032 | .000032 | .000000 |
| T407 | .51 | .000254 | .000178 | .000076 |

TABLE 12

FAILURE RATES BY EIC (ALL UNITS, 3 YR HORIZON) (CONT'D.)

| | | | | |
|---|---|---|---|---|
| T408 | .90 | .000287 | .000202 | .000085 |
| T409 | .66 | .000051 | .000031 | .000020 |
| T501 | .05* | .000020 | .000075 | -.000055 |
| T504 | .09 | .000131 | .000190 | -.000059 |
| T707 | .98 | .000259 | .000134 | .000125 |
| T708 | .22 | .000300 | .000346 | -.000046 |
| T90C | .66 | .000053 | .000000 | .000053 |
| T901 | .82 | .000058 | .000000 | .000058 |
| T903 | .94 | .000287 | .000145 | .000142 |
| T904 | .31 | .000072 | .000000 | .000072 |
| T906 | .28 | .000056 | .000057 | -.000001 |
| T908 | .46 | .000043 | .000000 | .000043 |
| T909 | .22 | .000039 | .000000 | .000039 |
| 4703 | .01* | .001754 | .002648 | -.000895 |
| 4704 | .00* | .000158 | .000539 | -.000381 |
| 4708 | .09 | .001499 | .001852 | -.000353 |

$\lambda_1$ - Failure Rate w/o OMT

$\lambda_2$ - Failure Rate /w OMT

* significant ($\alpha \leq .1$)

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